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Sanitary Conditions in the New York Subway.

While nobody ever intended that the New York Subway should be considered a health resort or rank with the city's parks as a "breathing place," there are very good reasons for demanding that it should be kept as clean and comfortable as possible. Although it is leased to a private company it belongs to the city, and it is possible to keep a fairly close control of its management. There has been considerable complaint about the heat, humidity and dirtiness of the road, but this journal has been of the belief that the grumbling regarding the first two points was hardly justified, however well grounded the criticisms regarding lack of cleanliness might be. This belief has been justified by the valuable report recently made by Dr. George A. Soper concerning the investigations he made during the last six months of 1905. In all about 2,200 chemical analyses of air, 3,000 determinations of the bacteria in air, and 400 analyses of oils, dusts, disinfectants and other substances were made, together with about 50,000 readings of temperature and humidity before the present system of automatic records was introduced. Such an investigation is manifestly neither the snap judgment of a space writer on a daily paper nor the biased opinion of a passenger who has become overheated by observing the disgraceful conduct of the subway train crews.

When the subway was built it was foreseen by the engineering staff that the temperature would differ considerably at times inside and outside it. Just how much it was wholly impossible to foretell, and accordingly steps were taken to keep records at numerous places of the readings of maximum and minimum thermometers and wet and dry bulb hygrometers, and recording thermometers were placed at several points. It was recognized further that any system of ventilation that could be introduced prior to the collection of definite data based on operating conditions would probably prove ineffectual. That this opinion was entirely justified is shown by Dr. Soper's statement that the ventilation produced by the train movements and the surface winds has completely hidden the effects of the fans and other devices tried experimentally during the period covered by his investigations. While he reports that the subway was unquestionably warmer last summer than the streets above, this heat he considers a far less serious menace to health than the strong drafts of cold air that enter the stations in winter. He also reports that the extra heat in the subway was far less than popularly believed.

Inasmuch as the subway has received so much criticism from people without the means to ascertain the actual facts, it is a matter of simple justness to the Rapid Transit Commission and its engineers to put on record the facts of the matter. For this purpose there is no need of describing the apparatus and methods employed by Dr. Soper, for his professional standing is an assurance that they were adequate for the purpose. The temperature of the subway air averaged 81.0° during July. In the week beginning August 4th it was 83.4°. Thereafter it declined very gradually until the latter part of September, when it was 76.0°. In the week beginning September 29th there was a slight rise to 78°. This was followed by a more rapid decline than had been experienced at any time before, and excessively high temperatures did not occur again. During the warmest period the temperature in the subway followed that of the outside air except in its most extreme and rapid changes. The average daytime temperature in the subway during July and August was 82.4°, while outside it was 76.8°. The maximum temperature observed in the subway during the hottest week was 88.2°, which was the same as that observed outside. On occasional days at other times the temperature in the subway was higher, the maximum being 95° at one station during a day in July.

Discomfort is caused as much by humidity as by heat in New York during the summer, and it is important to consider Dr. Soper's figures relating to it. He states that the relative humidity in the subway was generally less than out of doors, but the dew point was higher; in other words, the amount of moisture present was actually greater, but appeared less in the subway than in the open air. The average relative humidity during July and August was 57.5 per cent. in the subway and 60.6 per cent. out of doors. The greatest average relative humidity, 64.6 per cent., occurred during the week when the average temperature was highest. These observations and the temperature readings convince Dr. Soper that sensations ascribed in many cases to heat have been due in part to other conditions which it is practicable to improve. He thinks it is reasonable to believe that the public will adapt itself to the discomfort due to the unavoidable heat, if it is known that the subway air is reasonably pure and as agreeable as it is practicable to make it. It should never be expected that the air of the subway will be as cool and pure as the air of the streets, any more than that the air of the streets will be as fresh and pleasant as that of the country.

While the subway is thus given a good character so far as temperature and humidity conditions are concerned, its so-called sanitary administration is strongly condemned. The stations and toilet rooms are not cleaned properly, and what work is done is not properly performed. The ventilation of some of the toilet rooms is neglected and as a substitute alleged disinfectants of vile odor and worthless character are employed. The broken stone ballast at the stations is in a filthy condition, and unless it is replaced by concrete or some other smooth surface that can be flushed clean whenever necessary it will soon become as rank and vile as a gigantic cuspidor. These are not pleasant things to discuss, but in view of the importance laid on them by all authorities on sanitation, they must be mentioned. The subway carries too many people daily to warrant any euphemism in talking about its condition.

Street Pavements and Rails.

The problem of rails in streets has been presented to the city authorities of Hartford, Conn., in connection with the important improvements in street railway traffic proposed by the Consolidated Railway Co., the corporation which operates the electric railway properties of the New York, New Haven & Hartford R. R. Co. This company proposes to equip certain of its steam lines radiating from the city with the overhead trolley and to run high-speed interurban cars over them. The intention is to have these cars enter the city over the local street railway tracks. It is proposed to use the M. C. B. wheel on these cars; but this is impracticable with the rails now in service in the city, and the company has accordingly asked the city to consent to the use of T rails for the portions of the street track intended for the interurban cars. Mr. Frederick L. Ford, city engineer, has been making a personal investigation of the rail problem in thirty-seven cities, and corresponding with officials in other places, and as a result of this examination he strongly opposes the introduction of such track, favoring in its place a section like the Boston standard grooved rail. The problem as it has arisen in Hartford is unusually well defined, and for this reason it deserves the attention of city engineers.

In a general way it may be said that the objects of the street railway managers and the city authorities are so opposite in character that whatever agreement is reached must necessarily be in the nature of a compromise. The railway point of view is one of safety to traffic and minimum track expenses. Safety to traffic involves a consideration of wheel flanges, and for high-speed cars there is a general belief that the M. C. B. flange employed on steam roads is the best. Economy in track construction means the use of a T rail, not only on account of its merits for carrying traffic, but also because a track in which it is used does not present the troubles in the way of keeping grooves clean that arise when grooved rails are used. On the city's side the problem is entirely different. It is to require the use of rails which will offer the minimum obstruction to teaming and will cause the least deterioration in the pavements adjoining the rails.

In his report on the subject Mr. Ford brings out a feature of present practice that deserves more attention than it has generally received. This is the great difference between the conditions presented in the average narrow, crowded streets in a city in the Eastern States and those in the very wide streets of the cities in the Central and Western States. In the latter it really makes little difference to the vehicles using the streets what kind of rails and track construction are employed, for there is ample room for driving on each side of the track. In narrow streets, however, this condition is entirely reversed, for teams must be driven along and over the rails, and consequently the form of the latter becomes very important. The rail that may be good in Ohio and Indiana may be entirely unfitted for New England on this account. In fact, it is only necessary to turn to the files of the "Street Railway Journal" to find this fact acknowledged by street railway engineers. For example, Mr. A. L. Plimpton, of the Boston Elevated Ry., stated, in an article printed about a year ago, that "it should not be supposed for an instant that on any narrow streets where there is heavy team traffic, this form of construction (T rail) would prove to be durable, as in such places ruts of irregular depth would before long be formed alongside the rails." It is manifest that any form of construction which will result in such rapid deterioration of the pavement should not be permitted in narrow streets, and for this reason municipal engineers will probably be practically unanimous in supporting Mr. Ford in objecting to T rails in the narrow streets of Hartford.

The importance of interurban high-speed traffic will soon be so great in New England, however, that the railways' strong desire to employ M. C. B. wheels on such cars must receive careful attention. It is generally admitted that the thin flanges of the light wheels used on city cars are not safe for the heavy high-speed cars running across country. Reliance is placed on these flanges to keep the cars on the track, and the result of derailing a high-speed car may be so serious that even the importance of the maintenance of city pavements must give way to it. The fatal accident near Worcester a few months ago, when several people were killed or badly injured by a car leaving an interurban track, serves to show that the subject is a very serious one. Nevertheless it may be questioned whether the heavy M. C. B. wheel is needed; indeed, it is doubtful if its adoption on the cars running into Hartford would be a wise thing from a railway standpoint. Any street railway track built for such wheels would be practically unserviceable for the wheels of ordinary city cars, at least on curves, and would be worn out at a very rapid rate. This has been the universal experience where wheels of considerably different form are run over the same track. The costly special work is cut to pieces, and it is not at all unlikely that this damage caused by an attempt to run too many kinds of wheels over the same track is far more expensive than the cleaning of the grooved rails about which so much is heard. The city engineers who are responsible for the condition of pavements on narrow streets are accordingly justified in asserting that until street railway companies reach some approximate agreement concerning wheels, the only course for municipalities to follow is to insist on construction that will not result in a rapid destruction of pavements. This means some form of grooved rail for narrow, heavily traveled streets, and it is idle to assert the contrary from any experience on wide streets where teams do not have to follow the rails. Just what form the head of the rail should have will depend on the wheels used on the cars.

Some Misapprehensions Concerning the Panama Canal.

The Senate Committee on Inter-Oceanic Canals has suspended for the time being its investigation of the administration of the present Isthmian Canal Commission and is taking evidence of a more technical character bearing on the ultimate selection of the type for the trans-isthmian waterway. Although the President's letter transmitting the canal documents to Congress was clearly a recommendation of the lock plan formulated by the minority of the consulting board, a careful reading of that letter, which was printed in the "Current News Supplement" of this journal on Feb. 24, will show a distinct provision in the mind of its writer for the possibility of the ultimate selection by Congress of the sea-level plan. The acceptance of the lock plan by the President, especially a lock plan which practically precludes the ultimate transformation into a sea-level canal, is in all probability due in the first place to the recommendation of the commission, a body of the President's creation, which has apparently been a partisan of the lock plan from its first days in office, and to the probable lack of time for a deliberate examination and consideration of the lock plan. It is well, therefore, in the face of such conditions, which, with hasty Congressional action, might easily lead to a final decision that would cause regret for all future time, that the Senate Committee should take time for a thorough examination of every important detail of the matter, thus uncovering the many plausible but erroneous statements in favor of the lock canal and against the sea-level canal.

Although the Senate Committee's investigation as to the type of canal has not yet proceeded very far, it has brought forth detailed statements by the present chief engineer of the commission and by one or two of the members of the Consulting Board, the results of which have been printed and are now available for examination. Some interesting and important information has already been made public in this way and doubtless much more data of the same character will be disclosed in subsequent evidence. This is especially pertinent as to the estimates of cost of both the lock and sea level plans. There appears in the evidence of one of the American members of the Consulting Board some important information regarding the land damages which must be charged against the lock plan as arising in consequence of the terminal lakes, especially Gatun Lake. This evidence brought out before the committee last week confirms strikingly the editorial comments of this journal on the same point. It appears from this evidence that an owner of "worthless jungle" on the westerly side of the Rio Grande estuary near the Pacific end of the canal was awarded compensation from the new Panama Canal Co., prior to the existence of the present treaty between the Republic of Panama and the United States, under condemnation proceedings at the rate of about $2,000 per acre. Furthermore, it appears that the Isthmian Canal Commission has had to pay for considerable tracts of land in the vicinity of Ancon at the rate of nearly $1,150 per acre for unoccupied land, some of it hillside jungle on Ancon Hill so steep as to be absolutely unavailable for any useful purpose whatever. Furthermore, alleged owners of Rio Grande marsh land or "manglares" have set up claims against the United States on the basis of $500 to $1,000 per acre. It also appears that there are large numbers of other similar claims being made. These are facts, matters of actual experience, and represent land values fixed practically at the time the treaty with the Panama Republic was made. Indeed, the first award spoken of above was made a number of years prior to the present treaty. Those parties who imagine that ridiculous nominal values which held twenty to twenty-five years ago are to be the basis of settlement of land damages following the creation of Gatun and Sosa Lakes are recommended to take these facts home with them for further consideration. It was also clearly brought out in the same evidence that the two items of land damages and increased cost of maintenance of the lock plan will add not less than forty millions of dollars to the estimated cost of that project, making its actual cost not less than one hundred and eighty millions of dollars and perhaps considerably more. In any fair comparison of the costs of the two plans not less than this latter sum must be taken as the cost of the recommended plan.

In connection with this item of increased cost of maintenance of the lock plan it was conclusively brought out in the evidence before the Senate Committee that the cost of dredging in the sea-level prism between the terminal approach channels would be practically nothing, for the reason that neither the Chagres River nor any other stream whatever between Colon and La Boca can discharge any silt into the canal prism. All the silt of the Chagres is stopped in Gamboa Lake, while that of the Gatun River and several streams now flowing into the Chagres from the west would discharge their waters to the ocean through diversion or other channels entirely independent of the canal prism, leaving but a few insignificant streams, some of them dry for a part of the year, to be received in sedimentation basins before discharging their clear waters over weirs into the canal. Any statements, therefore, to the effect that any streams whatever discharge their sediment into the sea-level canal prism, and a number of such statements have been publicly made, are without any foundation whatever. The proposed sea-level plan has the distinct advantage of preserving the canal prism free from all silt deposition, whereas the lock plan presents ample opportunity for serious silting of its channel, thus entailing large annual charges for constant dredging. While the most of these points have been set forth in editorial comments in this journal, they are now confirmed by conclusive official evidence brought out before the Senate Committee.

Much emphasis has been placed upon the alleged shorter time required to pass a ship through the proposed lock canal than through the sea-level canal. This point has also been most effectually disposed of in the evidence before the Senate Committee. It would be an efficient and fortunate administration of the lock canal that could permit ships going in the same direction to leave a terminal port within one and a half hours of each other, especially at the port of Cristobal, as it would require at least that time for one ship to get out of the way of another in the flight of three locks at Gatun even if the locks were working under ideal conditions; and frequently they would not be so working. Under such circumstances it would be common experience for a ship to wait anywhere from four to eight hours before it could take its turn to pass the Gatun locks. Again, the amount of time during the year required for locks to be out of commission for necessary overhauling and repairs would be another unknown element of serious delay. It is well known that pretty much if not all of the three or four months of winter non-use at the Soo is occupied in repairs of the locks there. When these matters are taken into consideration it would not be surprising to find that the average time of actual passage through the lock canal as proposed would be at the least from fourteen to twenty hours or more, and from two to three times as long as a ship would require in a sea-level canal. It is to be remembered that in the latter there would be at least one-half the total time for a continuous procession of ships on their passage; and that at the worst, the interval between two ships, during less than one-half the total time, would be the short period required for the operation of a tidal lock never having a lift of over 10½ ft. or one-half of that at Sault Ste. Marie. For speed and celerity of passage, therefore, the sea-level plan offers advantages far superior to those which can attach to any lock plan whatever, which many years' experience at Suez has conclusively demonstrated by actual operation of a sea-level canal.

The time of construction for the two types of canals has already received much consideration in the evidence brought out by the Senate Committee. In the printed copies of that evidence some interesting information is disclosed. It is there officially shown that the Consulting Board laid out a complete system or method of attack of the excavation of the great Culebra cut, including the requisite trackage and provision for the transportation of the excavated material from the steam shovels, as has also been done by Mr. John F. Wallace, the former chief engineer of the commission. The data acquired by such treatment of this great feature of the work demonstrate that the entire cut can be made from Obispo to Miraflores in a period not to exceed ten years working but one shift of eight hours per day, after making all the reductions and allowances due to inefficiency of labor, interruptions of the rainy season such as washouts, slips and other similar incidents and to the requisite repairs and maintenance of the steam shovels. When it is remembered that it is perfectly feasible, in fact in some respects highly advisable, to work two shifts per day on this cut, the attainment of the estimated time of ten years for the work is assured beyond question. This conclusion stands in the face of a statement which experienced engineers and contractors will regret to see made by Mr. John F. Stevens, chief engineer of the present Commission. On pages 942 and 943 of his testimony, referring to the 40 ft. of rock excavation in the sea-level prism at Culebra, there occur the following observations: "Well, I do not know anywhere in the world where rock has ever been taken out under just these conditions—in other words, under as hard conditions as these would be. I have not studied up any plan yet whereby, either as engineer or contractor, I could start to take it out." It scarcely seems possible that any engineer of experience would hesitate to make an inland excavation in rock to a depth of 40 ft. below sea-level, inasmuch as such excavations are being made inside cofferdams in rivers and bays practically daily in all parts of the country, and yet Mr. Stevens states that he does not know how to do it. If such bugbears are to frighten the builders of the Panama Canal we may truly be discouraged of ever seeing a waterway across the Isthmus. It is probable, however, that the chief engineer did not intend to imply all that his words indicate to the reader. No water other than that of springs, such as may be found in any excavation and readily removed by pumping, can ever get into the bottom of the Culebra cut as required by a sea-level canal until it is permitted to come in. About 2,000,000 cu. yd. of rock are now being taken out of the bottom of St. Mary's river by enclosing the requisite space by two dams and excavating the enclosure in the dry at $1.36 per cubic yard, whereas similar work is allowed for by the Board of Consulting Engineers at $2.50 per cubic yard. A full description of this work was printed in The Engineering Record of March 3, and will show how unreasonable are any fears concerning rock excavation in the Culebra cut.

The preceding comments show what excellent results are being attained in the thorough examination before the Senate Committee. One can scarcely read the printed evidence as published without becoming clearly convinced of the wisdom and even the necessity of building this great trans-Isthmian waterway as a sea-level canal. The unfolding of that evidence clears away unfortunate obscurities which have enveloped the question. The idea that great locks, requiring complicated machinery to move out of the way 10,000 or 12,000 tons of movable obstructions every time a ship passes through the canal and to replace them after the passage, enhances in some obscure and not clearly explicable manner the convenience, safety and speed of navigation, is set forth in its true terms as an error. Similarly the bogies of exaggerated possible construction troubles are reduced to their true size, amenable to sound engineering treatment. The United States government needs a clear and open waterway across the Isthmus, which can be easily and economically enlarged if necessary in the future and not a restricted channel choked by obstructing locks liable to derange and endanger the navigation seeking it.

Some Economical Features of Concrete Construction.

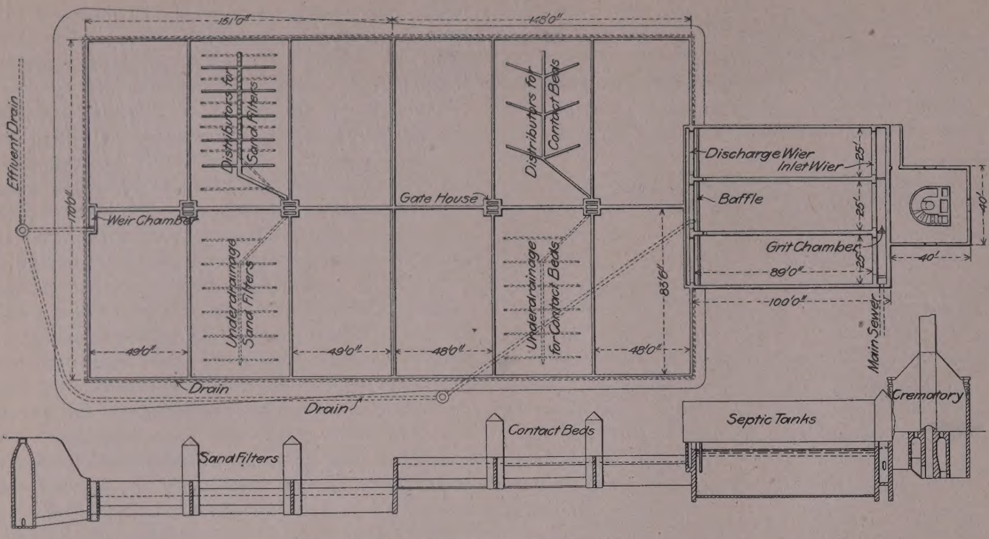
In a number of cases of recent designs for structures of concrete, with and without reinforcement, the estimated cost of the work was so far below the tenders for it that considerable criticism was received by the designing engineers. In one case in particular, where the structure was decidedly attractive as a piece of design, the cost of executing it proved so great that it was impracticable and was given up for a different construction. These differences between estimates and bids were not due to any difficulty in the way of obtaining materials for the concrete, but to a failure to appreciate the expense of putting it in place.

In designing steelwork, one of the maxims for the guidance of the drafting room is to employ duplicate pieces as much as possible. This is also a good rule in planning concrete, provided it results in using the same forms. The forms and not the finished concrete masses must be kept in mind in designing such work. An architect who recently congratulated himself on the saving in cost that would result from some thin concrete walls he had succeeded in introducing in the plans for a building, was much disgusted to learn, on the receipt of the tenders, that the molds for constructing them would be so expensive to frame and use that plain brick walls would be considerably more economical. It is difficult to appreciate fully without considerable experience the expense of constructing many of the concrete masses called for in engineering and architectural work. When concrete can be placed in large volumes its cost is low, but if it must be elevated several stories and placed in small molds filled with reinforcement rods its cost must inevitably be high. Moreover, if the columns, girders and walls require special forms which use up lumber so thoroughly that it has little subsequent value, this fact must also raise the cost of the finished work to a considerable degree.

Another factor to be considered in such work is the selection of proportions of ingredients which will give the desired strength and density with the minimum cost. This subject has been discussed so much that the really important fact of the whole matter is pretty well buried beneath the debates over details. This fact is the importance of the character of the sand, gravel or broken stone in any determination of proportions. In many localities there is very little possible choice of such materials, but it sometimes happens that a solution can be made between a number of varieties. When this is possible, the engineer has an opportunity to show judgment in determining the mixtures for different parts of the work. If a strong concrete is required, as Mr. L. C. Sabin points out in his excellent manual on "Cement and Concrete," rich mortar will not be able to make up a deficiency in the strength of the stone; but if a low strength is sufficient, and consequently a poor mortar is to be used, but little will be gained by having a very strong rock from which to obtain broken stone. In this case a rock that presents a good surface to which mortar may adhere is the principal requirement, and a very hard rock need not be insisted upon. It is for this reason that the customary specification requirements for 1:2:4, 1:3:5 or other proportions are inadequate. A number of engineers have abandoned such clauses and specify mortar mixtures only, leaving the amount of broken stone to be used for different parts of the work to the judgment of the resident engineer.

While it is probably true that the high cost of much of the concrete work done to-day might be reduced by paying more attention to working conditions when plans are drawn, it is also apparent that there are certain features of construction methods that may be improved. A large proportion of the cost of concrete work in buildings is for labor, and this labor charge is raised unnecessarily in some cases by a very natural tendency to have a large mixing plant for the whole work. The concrete turned out of such a plant must be wheeled and elevated, and it may be questioned whether a considerable reduction in labor charges could not be made in some cases by using small mixers driven by electric motors and capable of being moved readily from place to place. Materials could be delivered to these mixers regularly, and there would be no necessity of having a large number of men idle a considerable part of the time, as is often the case where the concrete is furnished from a central plant in wheelbarrows. It is possible to make connections with street wires in most cities, and contractors who have used electricity for power speak so favorably of it that the slowness with which electrically driven mixers and other plant are introduced is rather surprising. In a large amount of concrete work recently executed near New York there was practically no wheelbarrow transportation whatever except for the materials. The concrete was mixed very wet and discharged through troughs directly into place. The conditions were exceptionally favorable for such a method of construction, but any one who saw the operations could not help being impressed by its advantages.

The Beaver Creek Dam in Colorado, described in this journal on July 19, 1902, has been reported in daily papers to be leaking. Capt. R. M. Jones, of Denver, the engineer who designed and built the structure, states that these rumors are wholly without foundation. The total leakage through the dam is less than half a cubic foot a second and occurs through a 30-in. pipe connection with the steel plate lining. This connection was put in during construction to serve as a bleeder, and the leakage, trifling in amount, is but temporary. The dam is constructed of granite rubble, concrete and steel plates, the latter serving as a lining for the upstream face. Its length is 490 ft. along the crest; the thickness is 26 ft. at the crest and 192 ft. at the base, which is 96 ft. below the crest. The upstream face, which has the steel lining, is inclined 30° from the vertical, and the lower face 50°. The spillway is 60 ft. wide and is cut through the hillside around one end of the dam. The report of serious leakage probably arose from the fact that a large volume of water was recently discharged through this spillway.



Plan of Disposal Works for Sewage and Refuse.

SEWAGE PURIFICATION AND REFUSE INCINERATION PLANT, MARION, OHIO.

By Geo. H. Pierson, C. E., New York.

Marion, situated in the northern central portion of the State, is one of the busy railroad centers of Ohio, has a population of over 15,000, and is noted for extensive manufacturing interests, which has made its name known throughout the United States and many foreign countries. Situated in the heart of the famous Scioto Valley, the richness of the soil attracted early immigration. Within a radius of 20 miles are to be found the most prolific farming and fruit raising lands in the State. These interests have given the city the benefit of five railroads, one of which makes it the principal transfer station east of Chicago.

The city has water-works, sewers, gas works, an electric light plant, and street railways. For its population, this city has more miles of paved streets, stone sidewalks and beautiful shade trees than any other city in Ohio. The business blocks are substantial, and many private residences go far toward showing the modern ideas of the wealthy population. The topography of the city is such that ample drainage is secured for the system of sanitary sewers which are laid throughout the city, as well as for several miles of storm water sewers. The topography of the surrounding country is undulating, but rather flat. The Little Scioto River, about 2½ miles west of the city, is the principal stream thereabouts, and the surface water and storm water sewer effluent is led to it by public and private drainage ditches. The sanitary sewage is conveyed to this river through an 18-in. vitrified pipe.

The Little Scioto is a sluggish stream, and in dry weather the flow is small. Of late years it was demonstrated that it could not properly carry off the Marion sewage without leaving evidences of putrescible matter along the shores. This fouled condition of the river banks below the outlet of the outfall sewer resulted in many complaints and some litigation. The complaints were well founded and the litigation so urgent that the city voted to install a sewage purification plant. Several engineers made plans and estimates, during the period between 1901 and 1904. The plans of the writer were finally adopted by the Common Council in September, 1904, submitted to the State Board of Health for approval and after being favorably passed upon by that Board, contracts were made and the work commenced in October, 1904, and completed in September, 1905.

During the summer of 1904 careful gaugings at the outlet of the sanitary sewers were made and it was found that 250,000 gal. was approximately the flow in 24 hours. It was also found that a reasonably heavy rain would augment this flow by 100,000 gal., which was accounted for by the fact of there being many roof connections to the numerous cellar drains and some leakage into the main sewer. It was therefore considered that the future growth of the city was practically looked after for some years in building a purification plant having the capacity of 500,000 gal. per day. The plant as built provides for receiving the effluent from the city into a grit chamber from whence it is directed into all or each of three septic tanks, passing through the tanks and under suitable baffle boards it is discharged into an aerating chamber that extends for the width of the three septic tanks; from this chamber the effluent is led to gate chambers where it is discharged into one or all of the six contact beds. Passing downward through the contact beds the effluent is again led to gate chambers on a lower level where it is distributed in like manner on the sand beds, where the final purification takes place, and from which the purified effluent passes over a measuring weir on its way to the outfall sewer.

The perplexing question of providing for the disposition of the sludge which at times must be removed from the grit chamber has been solved by the erection of an incinerator, located adjacent to the grit chamber and septic tanks, which is provided with an evaporating floor sufficient in area to receive the sludge as it is pumped from the grit chamber into it. The moisture being evaporated, the residue is quickly burned.

This apparatus is also designed to destroy the garbage of the city, animal carcasses, night soil, and anything else requiring destruction by burning.

Surveys developed the fact that the fall in the outfall sanitary sewer from the city limits to the Scioto River was sufficient to permit of slight change of grade for about 1,000 ft., whereby the effluent is discharged at the purfiication plant at an elevation which admits of passing it through the processes of the plant by gravity.

For economical reasons a new 18-in. outfall was laid from the plant to the Rock Swale Ditch, which carries nearly as much water as the Little Scioto and empties into it a short distance above the old sewage outlet.

In summer the flow of the Little Scioto River falls as low as 500 gal. per minute. It could not, therefore, dilute the quantity of sewage and carry it away without more or less offence, therefore, the disposal works are designed to deliver not partially purified effluent, but that which is at all times non-putrescible, thus relieving the city of threatened litigation for the pollution of the river, and giving the best sanitary assurances to the inhabitants on the river below the city. Surface and sub-surface conditions, together with the great cost of filtering materials, compelled the restriction of areas as much as possible; therefore, to obtain the high rate of efficiency required, the raw sewage is thoroughly prepared prior to its application to the beds.

By this process much higher rates of treatment can be employed in the application of septic effluent to the coarse-grain materials of the contact beds than otherwise, and higher efficiencies of purification are secured by the treatment in the fine-grain or sand beds.

Prior to the completion of this plant, Marion suffered, as many cities do, from lack of provisions to care for the city wastes. Now the question of "where next can we find a dumping ground" no longer disturbs the Board of Health, and the sanitary conditions of the streets and alleys ranks very high among the cities of Ohio.

The plant is located about a mile west of the sparsely populated district of the city, a location that is not too far to haul garbage, etc., and one not likely to become thickly populated, owing to the large realty holdings of the railroad companies. For the accommodation of the present plant and providing for future extensions the city purchased about six acres of land at a cost of $2,500.

Sewer Connections.—About 1,000 ft. east of the plant the 18-in. outfall sewer is intercepted and the effluent diverted into a pipe of similar size, which runs parallel to the old sewer, but on a different grade to the plant. The old sewer is still maintained, by laying a new connection around the plant to a point where it again intercepts itself. The flow in the old sewer is shut off by means of stop valves. In case of flood or cloudburst this provision gives additional protection to the beds.

In case a general clean-out should be required, a connection is made between the septic tanks and the old line of sewer, which is controlled by a gate beside the tanks, and might be used at times of high water in the river.

As a precautionary measure provision is made whereby the effluent from the tanks can be delivered through the entire plant without passing through the beds; also the beds can be shut off to prevent back-water from the river. By these measures the beds are protected against unusually high water in the river and the excessive rain falls which sometimes occur throughout that section.

Septic Tanks.—Upon the delivery of the raw sewage at the plant, it passes through double screens having 1-in. mesh, and the foreign substances intercepted are easily removed from the screens and deposited in one of the dump holes of the incinerator, which are only 15 or 20 ft. away. The effluent then passes into the grit chamber, which is a compartment extending the entire width of the septic tanks, and divided into three units, corresponding in width to that of the tanks, and increasing in depth as it leaves the screens.

The sludge from the grit chamber can be pumped directly on to the drying floor of the incinerator, where the moisture is evaporated, after which the solid matter is burned.

By the manipulation of gates in the grit chamber the effluent can be discharged into one, two or all of the septic tanks. It is discharged into the tanks over a wall 2 ft. in thickness, where it falls a distance of 3½ in. to the surface of the effluent in the tanks. In its passage over the wall it is distributed in a very thin stream over the entire width of the tank.

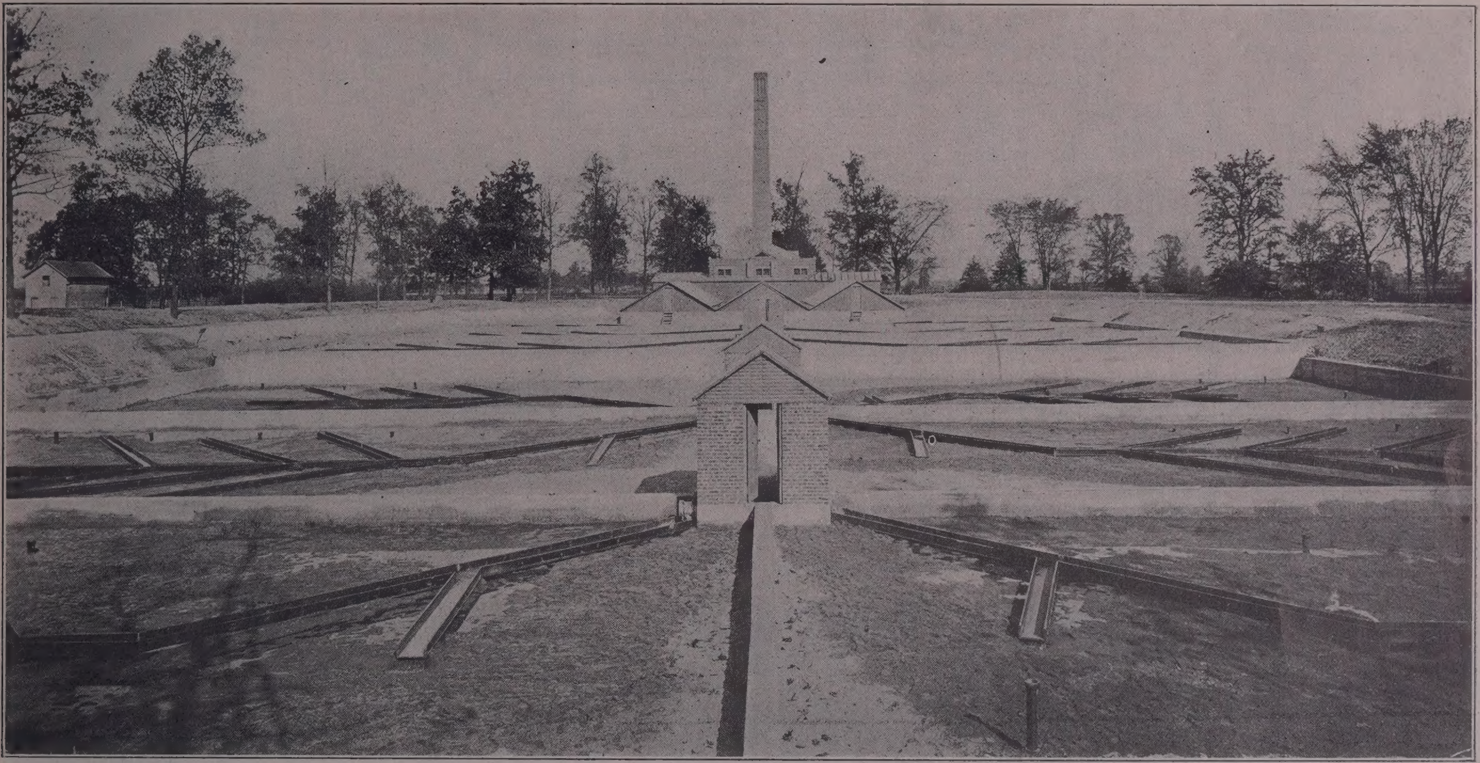
The septic tanks have a total area of 6,000 sq. ft., divided into three units of 2,000 sq. ft. each. They are 10 ft. in depth and have a total net capacity of 450,000 gal. The walls are 2 ft. thick, built of concrete, mixed in the following proportions: 1 part Portland cement, 2 parts sand and 4 parts broken stone. Care was taken to make the walls perfectly watertight.

The partition walls are each provided with an 18-in. opening and gate, by which communication is made for purposes of regulating the flow into each tank, or to operate each tank separately.

As the effluent passes through the tank, at a point 2 ft. from the lower end, it is obliged to pass under a baffle board built across the width of the tank and extending downward a distance of 5 ft. below the flow line, after which it is discharged over a weir in a thin stream into an aerating chamber, which extends for the width of the three tanks.

The process of aeration is considerably advanced at this point, as the effluent falls a distance of 2 ft. to the bottom of the chamber, from whence it is discharged into an 18-in. pipe leading to the contact beds. The tanks are entirely covered by substantial timber superstructure, which is finally covered with a combination of tar and gravel roofing. Doors are placed at convenient places for entrance and exit, and a runway walk in each tank provides means for passing through the tanks in all directions.

Some matters are too bad to write about, the atmospheric conditions inside a covered septic tank which is in operation may possibly be considered by some people to be one of them. The effluent discharged from a septic tank is in a state of putrescibility that is worthy of note, and in the operation of some plants gives rise to considerable unfavorable comment, even if it be proved that disease germs are not apprehensible in the vicinity. To alleviate this condition on the Marion plant, a large flue is constructed in the apex of the roof, which runs through the tank and is connected directly to the large chimney provided for the incinerator. The result makes it possible for those who wish to make close inspection to do so, without being subjected to the unsanitary hardships which usually follow, and offensive odors about the plant are practically eliminated.



General View of Filter Beds, with Septic Tanks and Incinerator in the Background.

The septic tank effluent is led from the aerating chamber to the first gate house in the contact beds by means of an 18-in. pipe, embedded in a concrete wall which is the central partition of the beds.

Contact Beds.—The contact beds have an effective area of 30,000 sq. ft., divided into six units of 5,000 sq. ft. each. They are divided by means of concrete walls 1 ft. thick and 5 ft. high The center wall is 2 ft thick and 5 ft. high, in it are contained the effluent, feed and discharge pipes, leading to and from the gate chambers. The beds are formed by excavating 8 ft. into the ground, at which point solid rock was encountered. From the top of enclosure walls the bank is sloped on an angle of 2 ft. to 1 ft.

The excavated material was distributed in a manner that drains the rainfall from the beds. For the protection of the beds against rainfall on the slopes, a 6-in. tile drain was laid around the entire plant back of the concrete walls, which discharges into the outfall sewer.

The contact beds are filled with 4 ft. of broken stone. This stone was supplied from the large local quarries, and was hauled by teams. The great quantity required, and the difficulty in holding teams during the preparatory periods and gathering of the harvest crops, made the filling of the beds very tedious.

The stone is of the limestone formation which is prevalent in this section of Ohio, and was considered by the engineer of the State Board of Health to be well adapted for the purpose. In placing the stone in the beds, the first foot in height is composed of pieces having an average diameter of about 2 in.; the upper 3 ft. is composed of pieces that range in size from ¾ to 1½ in. in diameter. The bottoms of the beds are brought to the required grade by puddled clay, well rolled.

Upon this carefully prepared bottom the system of underdraining pipes are laid. This system is composed of one main pipe 12 in. in diameter running longitudinally, and connected to it are eleven lines of laterals composed of horseshoe tile 6 in. in diameter. This arrangement is duplicated in the six beds.

The effluent is distributed over the top of the stone by means of wooden troughs, and delivered at points upon the surface which are intermediate to the drain pipes below. The bacterial oxidizing agencies working in the contact beds are very considerable, and generally speaking a uniformly non-putrescible effluent is obtained. Through the large pipe of the underdrain system the effluent is led back to a compartment in the gate house, and from thence started on its way to the sand filters for final treatment.

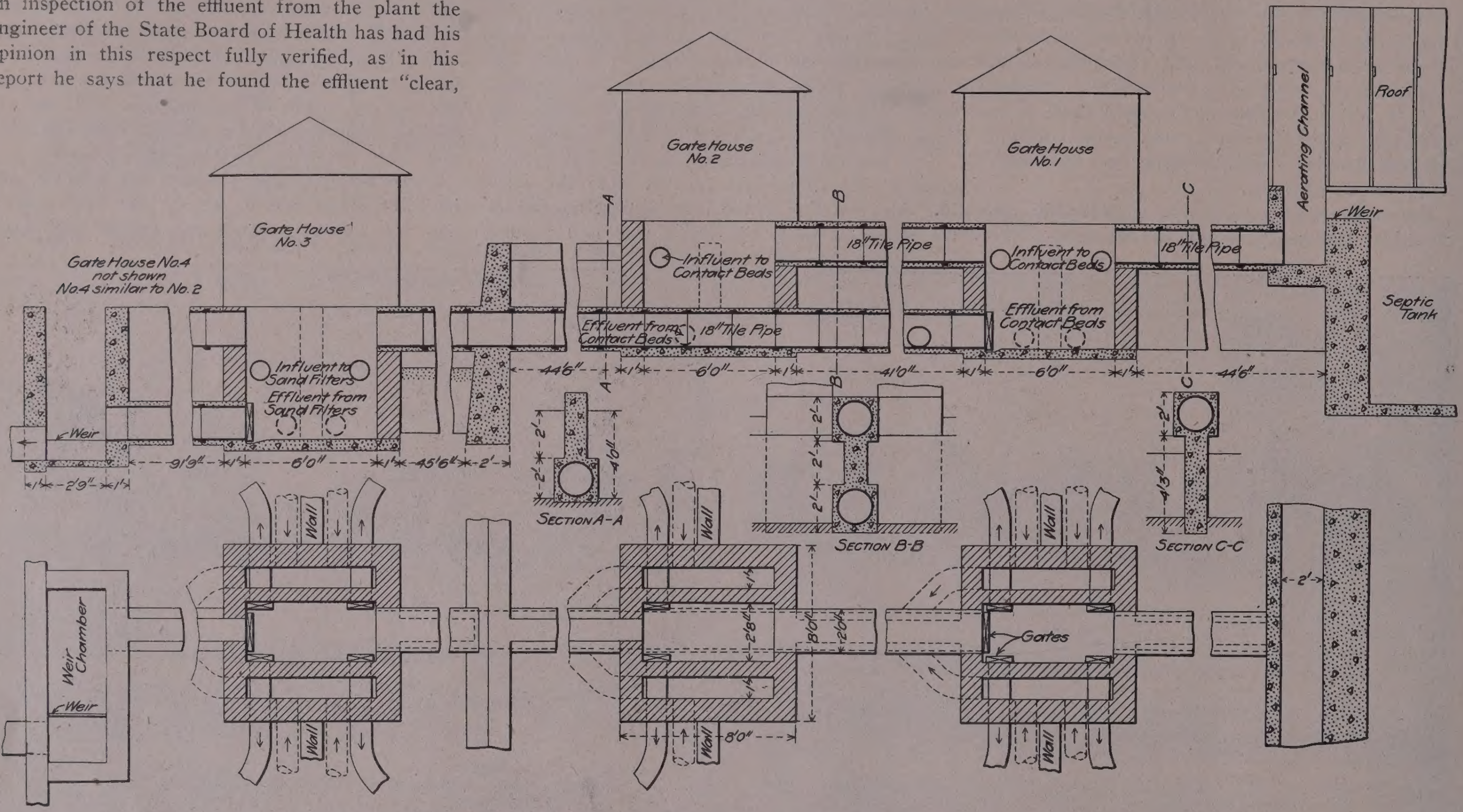
Gate Houses.—The contact as well as the sand beds are supplied with gate chambers, built of brick and 8x8 ft. in outside dimensions. Each house contains three parallel chambers, the central one of which is for influent, and the adjoining chambers for the effluent from the contact beds tributary to this gate house.

From the first gate chamber the effluent may be directed to one or all of the four contact beds of which it forms the center, and from the second chamber to the remaining two beds composing the group. From this chamber the effluent can be conducted to future beds should occasion demand.

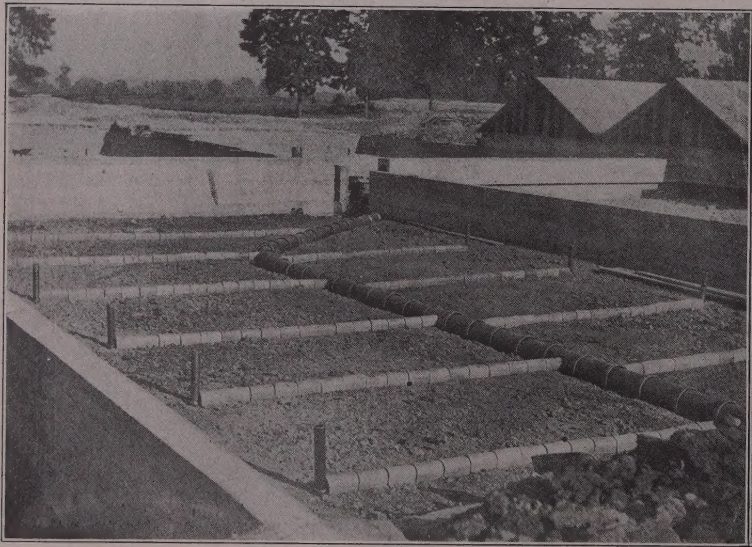
Intermittent Sand Filters.—The effective area of the sand filter beds is 31,200 sq. ft., divided in six units of 5,200 sq. ft. each. The surface of these beds is 4 ft. below the contact beds. They are divided similarly to the contact beds. The application of the effluent is the same, the distributing and controlling devices are duplicates. Three feet of filtering materials is used in these beds.

The underdraining system is covered for about a foot with broken stone ranging from ¾ to 1½ in. in diameter. Above this is laid 2 ft. of fine screenings, about like coarse gravel, and this material is covered with 8 in. of Lake Erie sand.

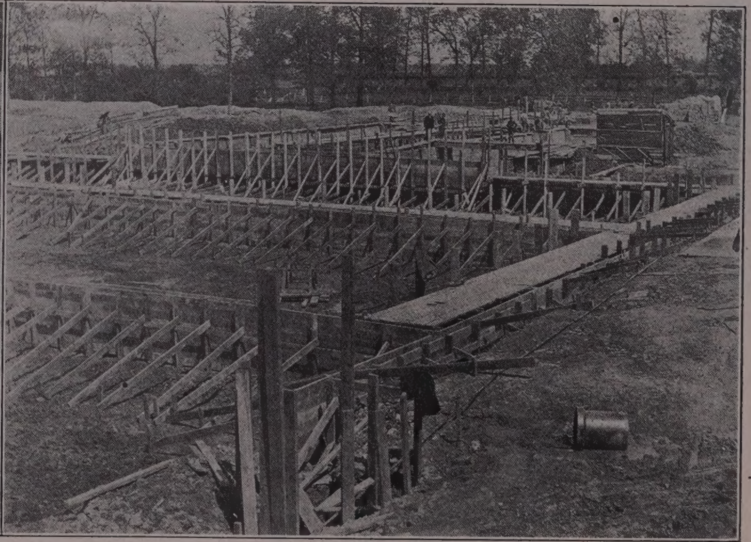
It was the original intention to fill these beds entirely with sand, but the local sand which the contractors had in view was not acceptable to the State Board of Health on account of its extreme fineness, and the unreliability of its component parts. After consultation with the engineer of the State Board of Health, he finally allowed the substitution of materials as heretofore stated. In this decision the engineer recognized the results of far-reaching investigations which have been made, showing that the principal part of the purification of sewage matter in sand-filters takes place within 4 to 6 in. of the top; and gave his opinion that the results from the beds described would be as favorable as though they were entirely filled with sand; as the final process in the sand beds would of necessity call for high rates of treatment, the filtering materials would also be required to be of coarse grain. In an inspection of the effluent from the plant the engineer of the State Board of Health has had his opinion in this respect fully verified, as in his report he says that he found the effluent "clear, colorless and odorless." At the lower end of the sand beds the purified effluent passes over a weir constructed for the purpose of measuring the discharge from the works.



Arrangemant of Gate Houses and Connections Between Septic Tanks and Filters.



Underdrains in Filter Beds.



Molds for Filter Walls.

Ventilation and Aeration.—Under this heading, which has been briefly alluded to in the description of the septic tanks, there is a feature which was not brought out, viz: The feed pipe from the septic tanks to the gate houses in the contact beds is never entirely filled except at time of very heavy rain.

The underdrain system in the beds is directly connected with the atmosphere by means of upright pipes which are placed at the end of each lateral drain. When the effluent has been discharged from the beds, should the doors of the gate house be closed, the powerful draft of the incinerator chimney pulls the air downward through the many standpipes, to the gate house and again through the partially filled feed pipes, and the air duct in the septic tank to the chimney, thus facilitating the re-oxidizing of the beds.

Refuse Incinerator and Sludge Evaporator.—Excavation for this apparatus, as well as for the entire plant, for the first 8 ft. in depth was made through about 2 ft. of natural soil where a very tough clay was encountered. This extended for a depth of 6 ft. to solid rock in most instances. The clay was so entirely filled with large and small boulders that the work of excavation was completed only after very hard pick and shovel work. A plow could not be used, blasting was tried, and after these efforts the work of scrapers was exceedingly difficult and expensive. The excavation for the refuse incinerator was made to a depth of 10 ft., the last 2 ft. being below the surface water line in the ground, which necessitated continual pumping in placing the foundation.

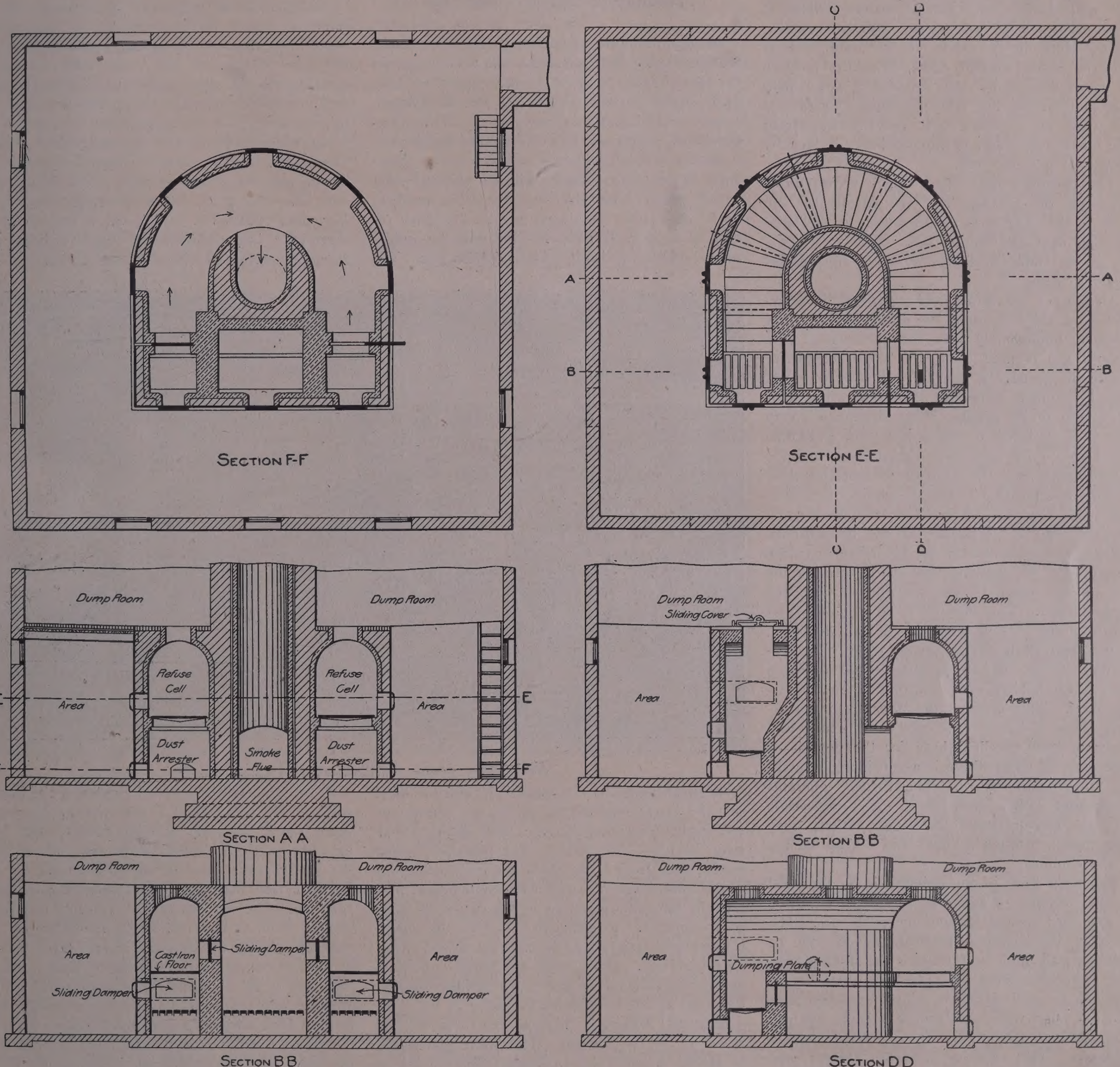
The incinerator building is a structure 40x40 ft. outside, built of brick with stone trimmings; the walls below the ground surface are of concrete, the southerly wall being 2 ft. thick and absolutely water tight, as this wall is the north wall of the grit chamber which is at all times filled with effluent. The incinerator proper is 20x20x12 ft. high, and a circular chimney starts from the center of the structure. In plan the furnace is one-half semi-circular and one-half rectangular. On the rectangular end of the furnace fire grates extend across its entire width.

In the center is a chamber which is 6½x5x8 ft. high, which is designed for the incineration of animal carcasses and very coarse rubbish. The heat from this chamber can be directed from one side to the other by means of sliding dampers. A dust arrester occupies the entire lower portion of the furnace, with the exception of that covered by the grates on either side of it. The ash pits and floor of the dust arrester slope toward the center of the furnace for the purpose of draining liquid seepage from the evaporating floor into a still deeper depression at the base of the stack.

This incinerator consists of an unusually large combustion chamber, purposely designed so that the deposits may have ample space for preliminary drying before burning, and also to provide for the difficult work of evaporating and burning the sludge from the grit chambers of the septic tanks, and the quantities of night soil which are required to be destroyed. In the destruction of these disagreeable substances, this feature is essential, as it affords the opportunity of burning the noxious fumes and odors. All the odorous gases from the drying cell are drawn downward through the fire on grates at either side of the incinerator, and are obliged to pass through the fire before entering the dust arrester on the way to the chimney. Such gases as can be destroyed are burned at this point, and those which it is impossible to destroy become so thoroughly relieved of moisture before they reach the top of the chimney that they do not fall. By the manipulation of dampers the temperature in the garbage cell can be regulated to suit, be there fire on one or all of the grates. The heated air is made to travel the entire circumference of the apparatus, then half way back under the evaporating floor before it reaches the chimney, thus acquiring great efficiency and economy.

The incinerator has a total grate area of 43½ sq. ft., of which 20 sq. ft. are in the middle combustion chamber or animal cell. The evaporating floor has an area of 170 sq. ft., all of which represents a burning surface The chimney is built of brick, 4 ft. internal diameter and 101 ft. high, which rests on a foundation of solid rock. For a distance of 50 ft. the stack is lined on the inside with firebrick, back of which the usual expansion space is provided. For the purpose of economizing space the stack was built in circular form to the point beyond the second story of the building, where the construction changes to rectangular form. At the point of this change in construction I-beams were used for the purpose of reinforcement. The cast-iron grate bars used in the furnace are of the ordinary type of stationary bars. They are cleaned by raking the ashes through them into the ash pit beneath.

About 2½ ft. above the bottom of the dust arrester a cast iron floor is laid covering the entire area. This floor is made of heavy cast iron plates reinforced with ribs. Six of these plates are so placed that they revolve, which affords convenience for dumping the refuse matter that accumulates on the floor into the dust arrester below, where it is easily removed through the clean-out doors. The apparatus is entirely enclosed by means of cast-iron plates 2x2 ft. in size and having 2-in. flanges ⅜ in. thick, which are bolted together. The entire furnace is lined with fire brick ranging in thickness from 4 to 16 in. as the situation regarding heat demands. All the fire doors are provided with baffle plates. These doors are placed at convenient intervals around the circumference of the apparatus for stoking the fires and garbage. Likewise clean-out doors



Sectional Plans and Elevations of the Sludge and Refuse Incinerator.

are provided for removing the ashes and rubbish from the dust arrester. All the openings in the brickwork are protected with fire bricks and are covered with cast iron sliding doors with the exception of the large doors which cover the animal cell. These doors, necessarily heavy, are lined with large blocks of fire clay and operated on wheels which run on a track outside the opening. The space between the incinerator and the area walls is covered with floorbeams and heavy planking upon which is laid water-proof tar paper. Then the entire floor of the building is paved with first quality of paving bricks which are well grouted with cement mortar, making it waterproof. This floor slopes from the outside to the stack in the center of the room, that it may be easily washed down. For the purpose of cleanliness about the building a large tank was built in the attic which is supplied with water from an excellent well 400 ft. away from the plant; this water is pumped into the tank by means of a water mill.

The openings in the floor which are used for receiving the garbage into the incinerator are 2 ft. in the clear with the exception of the large opening over the animal cell, which is 2¼x5½ ft., giving ample space for dumping any carcass without cutting.

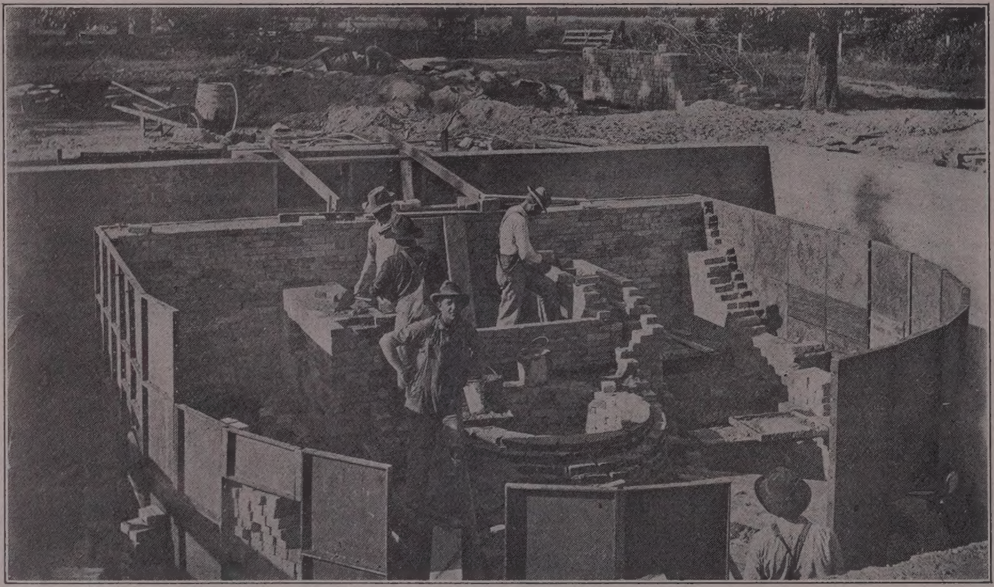
Method of Operation.—The garbage is delivered from the carts upon the dumping floor or is dumped immediately into the incinerator. As natural gas is used as fuel it does not matter where the garbage is dumped. That is to say, it may be dumped either on the evaporating floor or directly on the grates. If the substance is very wet it is desirable to dump it on the evaporating floor. There are seven dump holes, and the refuse matter will fall upon the evaporating floor in such position that it seldom requires any stoking. The heat can be directed from each grate to either side of the furnace as may be desirable, passing upward and over the top of the garbage around the cell, passing downward through the fire on the opposite side and thence into the dust arrester. The furnace is so designed that it can be operated with a direct draft if required, in the destruction of large quantities of dry, combustible matter. In the operation of the furnace a layer of ash is always kept on top of the evaporating floor. This protects the floor from the intense heat which is developed in the cell and forms a most excellent base for the deposit of night soil, of which there is a considerable quantity to be disposed of. The furnace operates throughout with a down draft. It is impossible for any odorous gases to escape without they have passed through the fires and out at the top of the chimney.

The main floor of the building is on the level of the ground. Wagons of any size can drive in and turn around without inconvenience. The space in the basement between the concrete or building walls and the furnace is the stoking area. This is reached from the outside by means of an inclined plane designed to allow the easy handling of ashes when the furnace is being cleaned. The rated capacity of the furnace is 30 tons in 24 hours. This capacity is at the present time 100 per cent. greater than is required. The furnace has had many very severe tests since it has been in operation and has been found to comply with every demand made upon it. There is no odor perceptible in its operation.

At the present time one man at $50 per month attends to the whole plant. When the system of garbage collection is more thoroughly perfected, an additional man will be required.

Costs.—Excepting the sewer pipe, all the materials for the construction of the works were purchased in Marion, and the labor so far as possible was given to its inhabitants. The total cost of the combined plant was as follows: Real estate, $2,500; incinerator, $15,000; septic tanks, $10,000; contact beds, $13,000; sand filters, $20,000; total, $60,500. To provide for payment of this amount the city issued 5 per cent. bonds which were sold at a handsome premium.

The plant was designed and built by the writer, who was appointed constructing engineer by the City Council. The incinerator was built under license from the Robt. L. Walker patents. The contractors were the Clinton Foundry & Machine Co., of New York.



View Taken during Construction of the Incinerator.

Subaqueous Shield Tunneling.

Subaqueous shield tunneling on the Baker St. & Waterloo Ry., in London, which was opened for traffic on March 10, has been carried on by a clay pocket method devised by Mr. Dalrymple-Hay, and described as follows in the "Times Engineering Supplement": The shield employed is a steel cylinder 10 ft. long and is of special design, in order to operate through water-bearing gravel under compressed air against a head of 70 ft. of water. To guard against a sudden inrush of water a steel trap is fixed near the middle of the shield, consisting of two diaphragms. The front diaphragm fills the upper half, and the back one the lower half of the shield, the bottom of the former extending down a few inches lower than the top of the latter. Any inrush of water is prevented from rising above the level of the top of the lower diaphragm, as it is maintained at that level by the compressed air in the tunnel, so long as the pressure is sufficient. Before the shield is operated a series of pot holes in the gravel ahead of the shield's cutting edge are bored and filled up with well-tempered clay. An annular ring of this clay 23 in. in advance of and 2 in. or 3 in. (measured radically) beyond the skin of the shield is thereby formed. This done, the shield is forced forward by hydraulic pressure for a length corresponding to the size of the iron segments forming the tunnel rings. In advancing the shield's cutting edge is buried in the tempered clay, while as the ground loses its support at the rear end, the tempered clay is exposed over the already completed tunnel. It may be pointed out that under ordinary circumstances an opening through gravel so bored under a river would at once subside; but by this method a layer of tempered clay is left behind with every advance of the shield. The air pressure, acting upon the clay, holds up the circular wall thus cut until the annular space between it and the iron rings has been securely grouted.

Questions of Safety in a Lock Canal at Panama.

From the Minority Report of the Board of Consulting Engineers for the Panama Canal.

The most plausible arguments advanced by advocates of a sea-level canal to justify its greater cost and the greater time required to build it are the alleged danger of carrying away the lock gates at either end of the summit level if a ship moving at speed should strike them, and the possible damage to structures through malice or in time of war.

An accident to gates, if it occurs, is most likely to result from a mistake in the engine room, the engineer sending the vessel ahead when the pilot signals to back, and then the pilot, noticing that the ship's speed is not being reduced and not realizing that the previous signal is not being carried out, signals for full power or perhaps signals so rapidly that he cannot be understood. One or the other of these successions of events has usually taken place when a ship has run into lock gates. The carrying away of a lock gate occurs but rarely, but it has occurred three times in the Manchester Canal. It has never occurred in the St. Mary's Falls Canal.

In the Manchester Canal the gates at the lower end of the lock were struck, the upper gates being open, the ship moving downstream, but in all cases the operating force was able to get the gates at the head of the lock closed, or so nearly closed that they came together and held back the water in the canal. If such an event should occur at Panama, where the locks are in duplicate, traffic through the injured lock would be suspended until repairs could be made. With duplicate gates in stock the repairs could probably be made and traffic resumed through the injured lock without a prolonged delay. In the meantime, traffic would be continued through the duplicate lock, and although, if the traffic were great, it would be subject to some inconvenience, yet it would be maintained.

If, however, the gates supporting the summit level should be carried away and the current flow unobstructed through the locks with no means in readiness to stop it, such, for example, as a movable dam, the result would be very serious indeed. It would require many days to lower the level of Lake Gatun sufficiently to render the task of closing the opening through the lock easy, and in the meantime the channel and the works below the lock might be seriously damaged and navigation suspended for weeks or months. The chances for such a disaster are so small that if the Panama Canal were intended for commercial purposes only, the great additional expenditure required to make it a sea-level canal would have few advocates, but the possible need of the canal for the passage of ships in time of war strengthens the argument for a sea-level canal and makes it necessary to consider with care the chances of such an event in ordinary canal operations, the facilities for handling and controlling the movement of ships which may be used, the precautions for safety which may be introduced in the operation of the locks, and the constructions which may be supplied to close off the current should it be set up.

We believe that in no ship canal in the world has such a disaster occurred as that imagined for the Panama Canal. If the accidents at Manchester Canal show that gates may be struck and destroyed, they also show that disaster may be averted even without special safeguards. Of all the possible movements of a ship at canal locks the one that involves the most danger of opening a summit level is when a ship bound down in that level approaches a lock, but by proper safeguards this can be made very small.

Distributing Troughs on Marion Filter Beds.

If a gate is struck by a ship upward bound the water pressure on the opposite side of the gate helps to resist the blow. By the use of two pairs of gates at each end of the summit lock all danger of opening the summit level by a blow on the downstream side of the lower gates is eliminated, as will be shown a little farther on.

The canal construction should provide long approach walls at each end of every lock or flight of locks so that lines can be put out quickly and handled readily and the ship held under perfect control. For this important purpose a long solid pier with suitable snubbing posts is vastly superior to mooring piles and floats, such as are used in some foreign canals. No canal in Europe is adequately provided in this respect, and the apprehensions of some members of the Board in regard to the hazards of navigation through lock canals may be due to the fact that their experience has been entirely with canals having this radical defect. With suitable approach piers and with rules duly enforced requiring ships to put out lines on arriving at the pier and to reduce speed to two miles per hour when moving along it, or to stop altogether several hundred feet from the lock, a great degree of security can be obtained. Such approach piers are provided in the lock plan herein recommended.

This plan also provides two pairs of gates at the head and two at the foot of each summit lock, so that a ship will always find two pairs of gates shut against it.

If the summit level is terminated by a single lock and the lower gate is struck by a ship upward bound, the gates at the upper end of the lock being open, the lower pair of gates at the foot of the lock having water pressure back of them will absorb the blow, and even if they are wrecked the second pair of gates, some 80 feet distant, will not be reached. The resistance offered by the first gates will almost surely stop the ship, and the rush of the mass of water, 80 feet in length between the two gates, will insure stoppage before it can reach the second pair. If the lower end of the lock is open and the upward-bound ship strikes the first pair of gates at the upper end of the lock its motion will be stopped by these gates, the miter wall and the water, and the second pair of gates will be left intact. We believe, therefore, that, by the use of duplicate or safety gates at each end of the summit lock, all danger of opening the summit level by an upward-bound ship will be eliminated.

If a downward-bound ship is approaching the gates from the summit level it will find at least two pairs of gates closed against it, of which the first will be sustaining no water pressure to weaken the strength available to stop the ship. While this case does not afford the absolute security shown in the case of ships moving upstream, the possibility that the ship will so completely wreck the first pair of gates as to continue its course to the second and seriously harm it is extremely small. A large lock gate is a massive structure, not easily wrecked. The gates of the Poe lock have been struck three times and injured more or less, but they continued to support the summit level.

The provision of duplicate gates at each end of a lock herein adopted is an unusual precaution. It has been recently adopted in part at the St. Marys Falls Canal, where duplicate gates are now operated regularly at the lower end of the Poe lock, but the upper end is not similarly protected. In the additional lock now projected at that canal safety gates are to be provided at each end. The approach piers, the extent of which greatly affects the safety of a lock, are excellent at the St. Marys Falls Canal and far better than at any other ship canal, and doubtless have contributed to the remarkable record of immunity from serious accidents. This canal has now been in operation a little more than fifty years and a traffic aggregating about 360,000,000 tons net register has passed through it, with no accidents seriously obstructing navigation. It is the best example existing not only of the capacity of a lock canal for a great traffic but of the safety with which this traffic can be handled with suitable equipment.

In view of these facts relating to the operation of canals not as well provided with safety appliances as proposed for the Panama Canal it appears fanciful to enlarge on the dangers of a lock system; but even the small risk which a lively imagination might still assign to a lock canal can be substantially diminished, since it is not impracticable to stop the flow from a summit level, if once set up. Several devices have been built to control the flow of water from the summit level in case lock gates should be carried away. More than forty years ago a pair of gates provided with powerful brakes to check their movement while closing in a current was placed about 3,000 ft. above the locks in the St. Marys Falls Canal. The gates were removed about fifteen years later when the canal was deepened, before any occasion had arisen to use them for the purpose intended. When the channel was deepened a construction was adopted consisting of a series of wickets, each so small that its movement could be controlled by machinery of moderate power. The wickets were carried by a swing bridge, and when not in use the bridge was open and the wickets were then on land, where they could be inspected and repaired. The canal force was trained regularly in the handling of this device so that they might work efficiently in case of actual need. For such experimental practice the same procedure was followed as in a real emergency, viz., the bridge was swung across the canal and the wickets lowered one by one, their lower ends resting against a sill at the bottom of the canal, the upper ends supported by the bridge. After about eighteen years the canal was again deepened and the device removed before any accident requiring its use had occurred. A modified form of the device was built at the Canadian canal at the St. Marys Falls about ten years ago, but is yet untried, and another is about to be supplied for the American canal. The problem of working out a satisfactory device for this purpose in the deeper channel of the Panama Canal is a difficult one, but no doubt is entertained that a solution can be made. For such appliances the sum of $2,000,000 is included in the estimate of cost.

A lock may suffer other injuries, and will require repairs, during which navigation through it may be interrupted. For this reason, principally, duplicate locks are provided, so that if one is under repair navigation may continue uninterrupted through the other. It is seldom that a lock is put out of use, and the simultaneous disabling of two would be very unlikely.

The canal structures most exposed to injury through malice or in time of war are the locks and wasteways. In the sea-level canal there would be three such points—the tide lock at Ancon, the sluices at the Gamboa dam, and those between Ancon and Pedro Miguel, the last named being of small importance. There will be five in the lock canal herein advocated—the locks at Gatun, Pedro Miguel, and Sosa, the sluices at the Gatun dam, and the sluices or wasteway in the Ancon-Sosa saddle. The latter is so small and may be so securely founded on rock but little below the level of the canal that no possible injury to the structure would interfere seriously with navigation. The Ancon lock of the sea-level canal and the Sosa locks of the summit-level canal are equally exposed to attack by a naval force.

While it is conceivable that a malicious person or a crank might carry enough concealed high explosive to injure a lock gate or a sluice, experience of many years of perfect immunity in all the ship canals shows that this is not a real danger. The only disaster to be seriously considered is one that might be inflicted by a hostile force in time of war. If the enemy had control of the coast, or occupied territory inland in the vicinity of the canal, enough high explosive could be carried through the tropical jungle by a small force to destroy any of the lock gates or sluiceways, or to sink a ship. In order to open the summit level effectively and cause a suspension of navigation for a long time it would not only be necessary to destroy two pairs of gates, but also the device already referred to for closing the channel in a current. So large a force and so much time would be required to do all this that it could be effected only by a force superior to the strong guard which in time of war would certainly be stationed at every important canal structure.

It has been suggested that a vessel carrying a large quantity of concealed dynamite could be exploded in a lock and wreck not only the gates but the masonry. While the execution of such a plan is extremely improbable, there are three places where it might be attempted in a summit-level canal and one in a sea-level canal. In either case the duplicate system of locks would reduce the hazard very much.

But it must be remembered that it is easily possible to block a sea-level canal by the sinking of a vessel in its channel, either by design or by accident, such an accident, for instance, as that which caused the steamship *Chatham* to absolutely block the Suez Canal and suspend all traffic through it for a period of nine days, from Sept. 27 to Oct. 6, 1905.

This accident occurred in time of peace in a sea-level canal, thirty-six years after its completion. During the period of fifty years since it was built there has been no such protracted interruption to traffic in the lock canal connecting Lake Superior with the lower lakes, and the delays in the channels away from the locks have constituted the most serious interruption to traffic on that waterway.

It is therefore evident that the structures are not the only vulnerable points in a waterway across the Isthmus. The locks and wasteways could be much more readily guarded than the whole length of the canal. At almost any point on the sea-level canal the attempt might be made to explode dynamite under a passing ship, which, if successful, would close the narrow channel effectively. There are many places on the route where this could be done more safely to the hostile party than at the locks. To this danger ships would be much more liable in the narrow channel of the sea-level canal than in the broad waterway of which the lock canal mainly consists.

We believe that unless the canal were declared neutral by general agreement among civilized nations the maintenance of navigation through it in time of war and with an active hostile force in the vicinity would be difficult; but the danger under this condition does not differ greatly whether the canal be a sea-level or a lock canal.

Possible injury by earthquakes to a canal across the Isthmus has received much discussion and much has been made of it by opponents of any canal. It was treated fully and fairly by the first Isthmian Canal Commission, and the following opinion expressed, which is entirely applicable to the lock canal herein advocated, and in which we concur: "The works of the canal will nearly all of them be underground. Even the dams are low compared with the general surface of the country, and, with their broad and massive foundations, may be said to form part of the ground itself, as they are intended to do. The locks will all be founded on rock. It does not seem probable that works of this kind are in any serious danger of destruction by earthquakes in a country where lofty churches of masonry have escaped with a few minor injuries."

The comparison as to the relative safety of ships in the two types of canal must relate principally to conditions at the locks in the summit-level canal and in the narrow channel of which the sea-level canal mainly consists. While there will be a short section of channel only 200 ft. wide in the summit-level canal it will be so short that it will not affect in an important degree any conclusions that may be drawn if it be neglected; and similarly, while there is to be one lock in the sea-level canal there are six in the summit-level project, and the tidal lock of the former may be neglected in this connection.

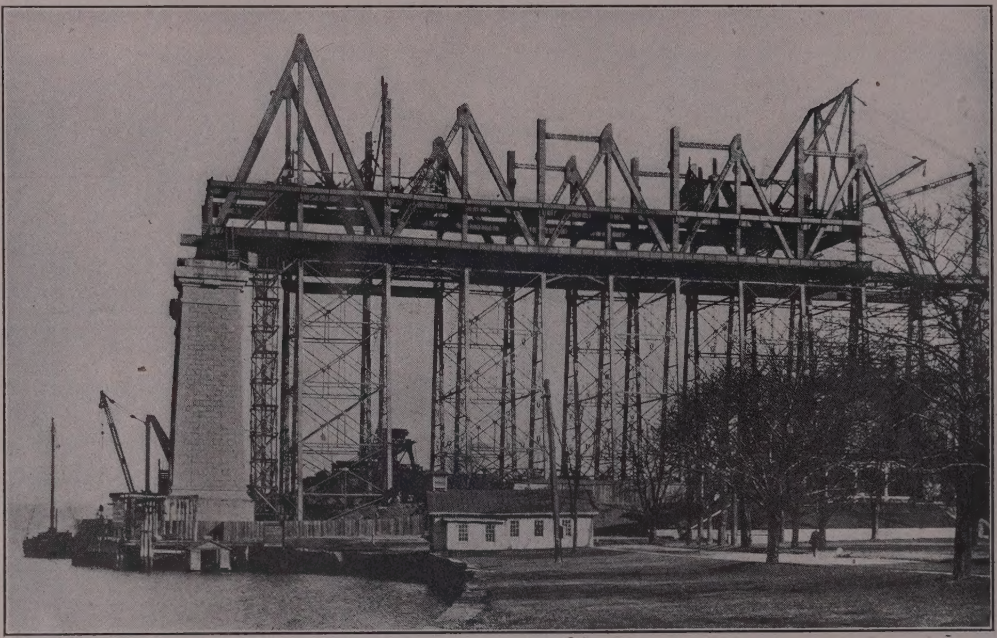
A lock is a short section of canal, with vertical sides, in which ships are moved at a low speed and under perfect control. A ship is in much less danger of injury in a canal lock than when landing at a pier in the most favorable conditions with no wind or current. Experience at the St. Marys Falls Canal, where no vessel has been seriously injured in a lock during fifty years of continuous use, should be conclusive on this point. Danger to ships in a canal is not at the locks, where they are moving slowly and under control, but in the excavated channels elsewhere through which they pass at speed, and where, if the width is insufficient, groundings are likely to happen, and if the sides are rocky and rough, serious injury to the ship will probably result.

What has been said above as to the relative danger to ships in locks and in narrow channels is equally true in regard to delays. From the records of the Suez Canal there was obtained for the first Isthmian Canal Commission a statement showing delays to traffic from ships grounding during a period of eight months, from January to August, 1899, inclusive. No delay of less than six hours was included. Groundings of more than six hours were 15 in number, the aggregate delays to the grounded ships being 292 hours 29 minutes. In 14 of the 15 cases the channel was blocked so that other ships could not pass, the total time during which the canal was blocked being 185 hours 40 minutes.

With duplicate locks, as proposed for the Panama Canal, navigation would [illegible] be delayed at the locks, as it would [illegible] improbable that both of them would [illegible] of use at the same time. The excavated channels of the St. Marys and St. Clair rivers are much wider than the sea-level canal would be, yet they have been blocked on several occasions. Only a small part of the loss to navigation was borne by the vessels causing the blockade. In one instance, when the blockade continued for five days, 332 vessels were delayed, and the loss to navigation amounted to a large sum, estimated to be $600,000. The loss in such a case increases very rapidly with the density of the traffic. In comparing the two projects it must be kept in mind that the broad channels and duplicate locks make a blockade almost impossible on the summit-level canal, while the narrow waterway of the sea-level canal is far more liable to interruption.

If the sea-level canal should be built as now planned it would serve only a temporary purpose; a strong demand would arise within a few years for a broader and safer channel. This demand, we believe, would be made much sooner than any demand for a material change in the summit-level canal built as herein recommended.

It is not intended in this discussion of the relative safety of and delays to ships in the two canals to give an impression that ships will be subjected to a high degree of hazard or delay in either, but to show that the summit-level canal is superior in both respects. The sea-level canal could be made equal to or better than the other by widening the channels a sufficient amount, but the cost of this increased width would be very great.

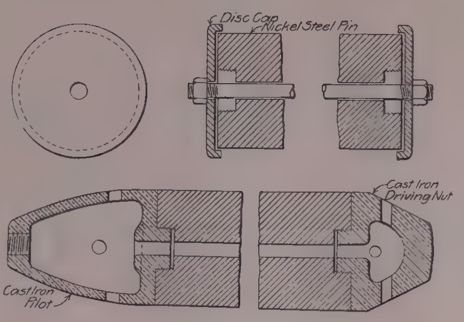


Erection View of Island Span of Blackwell's Island Bridge

A Defective Sewer in Atlanta collapsed several months ago, but as the arch was about fifteen feet below the surface and gave way so gradually that the falling material was carried along by the current, there were neither surface nor subsurface indications of any trouble. Finally, however, the earth crust over the break weakened so much that its arching action disappeared, with the result that a horse was dropped through the pavement into the pit below, where it was speedily suffocated by gas escaping from a pipe that was broken in his fall.

Erecting the Floor Systems and Lower Part of Trusses, Island Span, Blackwell's Island Bridge.

All of [illegible] verticals and diagonals in the trusses of the Island span of the Blackwell's Island bridge, New York, are made in half-lengths, with pin connections or riveted splices at the middle height of the trusses. This detail, together with other features of the design, make it possible for the lower half of the trusses and both upper and lower floor platforms to be erected and completely assembled before the upper parts of the trusses are erected.



Details of Pin.

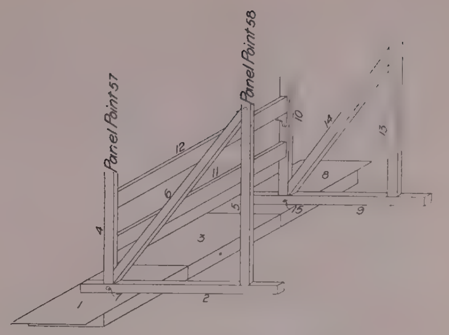


Diagram Showing Order of Erection.

Members of the Lower Part of an Island Span Truss.

This enables about two-thirds of the steel, including the heaviest members, to be handled by a very simple traveler before a tall traveler is put in commission for erecting the remainder of the structure, and much economy and rapidity are effected by this arrangement of the work. Truss erection was commenced at pier II (Eng. Record, March 4, 1905), where the lower half of the first panel of both trusses and the corresponding floor members were hoisted and assembled by a 65-ton stiff-leg derrick with 85-ft. boom, seated on the first panel of falsework and in the bridge axis.

The sequence of operations was as follows:

The pedestals and transverse girders on the pier having been already erected, as described in previous articles, all of the members for the first panel were loaded by a gantry in the storage yard (Eng. Record, Feb. 17, 1906), on cars on a standard-gauge surface track located 75 ft. north of the bridge axis. All the materials were hoisted from the cars to the falsework by the derrick which, with its boom extending out 75 ft. horizontally, was not unduly stressed, nor was any trouble occasioned to the platform or anchorages by the heaviest member which weighed 60 tons.

The south pedestal being in place, the succeeding members of the sub-panel were erected in the order indicated by the numerals on the accompanying diagram, namely 1, the south section of the pier girder, 2 the south lower chord L57-L58, 3 the middle section of the pier girder, 4 the lower section of the south post L57-U57, 5 the south post L58-C58, 6 the diagonal L57-C58, 7, the south pin L57, 8 the north section of the pier girder, 9 the north lower chord L57-L58, 10 the lower section of the north post L57-U57, 11 the lower floorbeam 57, 12 the upper floorbeam 57, 13 the north post L58-C58, 14 the north diagonal L57-C58, 15 the north pier L57. Upper and lower floorbeams 58 were erected and finally the stringers and lateral systems for both floor platforms in panel 57-58 were assembled.

The derrick then erected on the upper floor stringers, traveler No. 1, which, without rigging, weighs about 250 tons. This traveler was illustrated in The Engineering Record of March 11, 1905, and essentially consists of two boom derricks on a 46x44-ft. horizontal steel platform mounted on four 4-wheel trucks running on two standard-gauge tracks 40½ ft. apart on centers. The platform is built of heavy longitudinal and transverse girders and X-bracing and has at each of the front corners a 60-ft. steel mast and an 85-ft. steel boom of 65 tons capacity. The masts are X-braced together and have stiff legs pin-connected to the longitudinal sills. Each boom is rigged with a 12-part topping lift and a 10-part hoisting tackle, operated by a special three-drum, six-spool hoisting engine weighing 63,000 lb., and having a 100-h.-p. boiler, both manufactured by the Lambert Hoisting Engine Co., Newark, N. J. The engine is special in that all the drums and spools are commanded by clutches with hand-wheels located at a single point within convenient reach of the operator. The engine, boiler and rigging, bring up the total weight of the traveler to about 560 tons.

The erection of the traveler was completed Oct. 19, and it was put in immediate operation to erect the second panel of the bridge, the hoisting engines being located on the ground at this time. After this panel was completed, the traveler moved on to it, leaving space on the first panel for the construction of an independent 39x40-ft. steel rolling platform with a solid deck of 3-in. planks, which was mounted on eight double-flange wheels on a 35½-in. gauge track and followed the traveler carrying the hoisting engines, boilers, coal, water and other supplies. The traveler advanced one full panel at each move and was always placed with the forward end resting on the last sub-panel point floorbeam erected. In each position it erected two full sub-panels of the structure up to the middle of the trusses, and the best record was the erection of this amount of steel in five days, including the movement of the traveler. About 2 hours are required for each advance of the traveler, the time being occupied almost entirely by clamping and unclamping the anchorages, which are scrupulously adjusted in every position. The actual movement of the traveler is accomplished in about five minutes. About 25 men are required to operate the traveler, and it has hoisted a single piece of a maximum weight of 78 tons using both booms simultaneously for this purpose. The largest amount of steel erected by the traveler in one day was 335 tons.

The largest single piece handled for this span is the 105-ft. 78-ton lower section of the main diagonal L59-C57 which, as has already been described, was at first intended to be erected in two pieces and afterwards longitudinally spliced together, but was eventually shop-riveted complete on account of the flexibility of the long and slender halves. The first one of these great members was erected on Oct. 23, almost immediately after the traveler was put in commission, after which the erection steadily progressed until Jan. 1, when all operations were indefinitely suspended on account of a strike. At the beginning of the strike there had been erected in all about 6,000 tons of steel, the lower half of the trusses being assembled except in the two last panels nearest pier III. The regular sequence of operations in assembling the successive panels was as follows: The front of the traveler always being set at a sub-panel point so as to clear the main lower-chord pins, the lower-chord sections are first assembled, then the floorbeam at the sub-panel point, the lower laterals, the main diagonals, the main vertical posts, the sub-diagonals, the upper floorbeams, and the floor stringers. The upper ends of the main diagonal members are temporarily connected and supported by 14-in. wooden pins, called toggles, which are passed through their 16-in. pin holes. The lower ends of the sub-diagonals are permanently connected and all connections at the lower chord panel points are completed and the permanent pins are driven.

As the lower-chord panel points are easily accessible working platforms can be quickly built there on the lateral diagonals. The lower-chord pins are driven by a 5,000-lb. ram suspended by a light tackle attached to its center of gravity. The ram is made from a 12x12-in. steel billet 10 ft. long, having transverse horizontal holes 2⅛ in. in diameter, bored through it 3 in. on each side of the center, to receive U-bolts by which it is suspended, the ends of the rams are slightly rounded and six handles of bent rods are clamped to it at equal distances apart, to enable the men to swing and guide it.

The largest lower-chord pin is at 63; it is 18 in. in diameter 6 ft. 4¾ in. long and weighs 5,100 lb. Some of the top-chord pins are a little longer and heavier, but all of them are alike in being simple nickel steel cylinders with a 2-in. hole bored through the axis and counterbored to a diameter of 6 in. and a depth of 2½ in. at each end. The small hole provides for a 1⅞-in. screw rod by which the permanent recessed end discs are secured to the pin instead of nuts, and the 6-in. recesses in the ends are tapped to engage screw threads on the shouldered ends of the hollow cast-steel driving nuts and pilot nuts. The pilot nuts are from 26 to 28 in. long and are bored and tapped at the point to receive small diameter toggle pins which may be previously inserted to start the connection when the pin holes do not fully register at first in the different connecting members.

The bridge was designed and is being built under the direction of the Department of Bridges of New York. The contract for the manufacture and erection of the superstructure was awarded to the Pennsylvania Steel Co., Mr. J. V. W. Reynders, vice-president, Mr. Thos. Earle, superintendent of bridge and construction department, Mr. Fred W. Cohen, engineer of erection, Mr. L. N. Gross, general foreman of erection. The method and plant of erection was described in The Engineering Record of March 4, 11 and 18, 1905, February 17 and 24, and March 3, 1906.

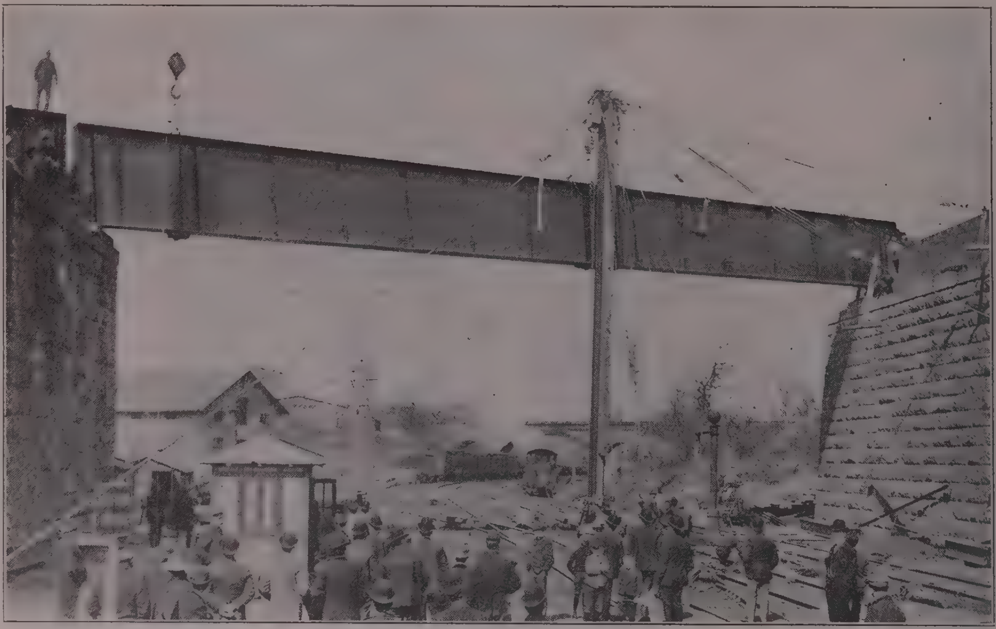
The Gin Pole Erection of a Long Span Plate Girder Bridge.

In the 33d St. improvement, near East Fairmount Park, at the Girard Ave. entrance, Philadelphia, 33d St. is carried over the tracks of the New York Division of the Pennsylvania Railroad and over the Subway Division of the Philadelphia & Reading Railway Co., on a total of five spans of deck bridge, made with three plate girders to each span, longest span being about 109 ft. with main girders weighing about 35 tons each. The girders have 7/16-in. web plates, 108 in. deep and about 15 ft. long, and the flanges consist of pairs of 8x6x¾-in. angles and 20 in. wide cover plates. The flange angles are each made in two pieces, with the joints staggered on opposite sides of the web and spliced with cover angles. The ends of the girders have bottom flange sole plates bearing on the narrow transverse vertical webs of cast steel pedestals each stiffened with five longitudinal webs. At the expansion ends the pedestals are seated on nests of rollers, grooved to engage guide strips in the centers of bed plates made with longitudinal bearing ribs riveted to 1-in. base plates.

The girders were riveted up complete in the shops and were shipped to the site, each girder being loaded with its web in a vertical position and having pivoted bearings on two flat cars, separated by one idler car, which delivered them between the abutments on tracks about 50 ft. below the bridge floor. They were unloaded from the cars and placed in their final positions on the pier seats by single operations effected by a gin pole of 12x12-in. timber, 60 ft. long, bolted together and reinforced by a pair of 12-in. channels. The top of the pole had a square shoulder, beyond which the timber was dressed to make a cylinder 10 in. in diameter and 2 ft. long, which engaged a 1¾-in. thick spider about 3 ft. in diameter. The spider plate was bored with six 2-in. holes to receive shackles for triple tackle blocks, by which the pole was secured in a position inclined 2 or 3 ft. from the vertical, so as to overhang its load. The opposite ends of the tackles were attached to single wire rope guy lines. The fall lines led directly down the gin pole and through snatch blocks to an American Hoisting & Derrick Co.'s double drum, four-spool hoisting engine.

The gin pole was erected and set in position by use of a stiff-leg derrick, not shown in the picture, which was seated on top of the embankment back of the bridge piers, and operated by a Mundy double drum, two-spool engine. The girders were lifted in two slings each made of 1½-in. chain, with rings shackled to the lower block of a four-part hoisting tackle. The upper blocks of these tackles were shackled to the opposite ends of a balance car about 5 ft. long, made of a pair of 15-in. channels, carried on steel pins resting on top of the channel sides of the gin pole. The tackle blocks were hung from heavy links carried on pins at the ends of the balance bar. Both tackles were simultaneously operated and raised the girder to a height about 40 ft. in about two minutes. After the girder was raised to the required elevation it was swung through a horizontal angle of about 90 deg. by the use of the derrick which had erected the gin pole, and was connected to it by the tackle, as shown attached to the end of the girder at the left. After one girder was erected the gin pole was moved by the stiff-leg derrick, seated again on a sill piece, and erected the second and third girders successively of each span.

The floor beams and stringers were unloaded from cars under the main girders and hoisted by the stiff-leg derrick at the left. This delivered them to a jinniwink derrick, which moved on the stringers and assembled them in advance and also assembled the buckle plates which covered them.



View of Girder and Gin Pole used in Raising it to Position.

The field rivets were driven with Chicago pneumatic hammers, operated by a Chicago pneumatic air compressor, fitted with a special automatic cut-off that closed the steam valve whenever the pressure in the compressed air receiver registered 100 lbs., and opened it when it fell to 90 lbs. Steam was supplied from an independent vertical boiler.

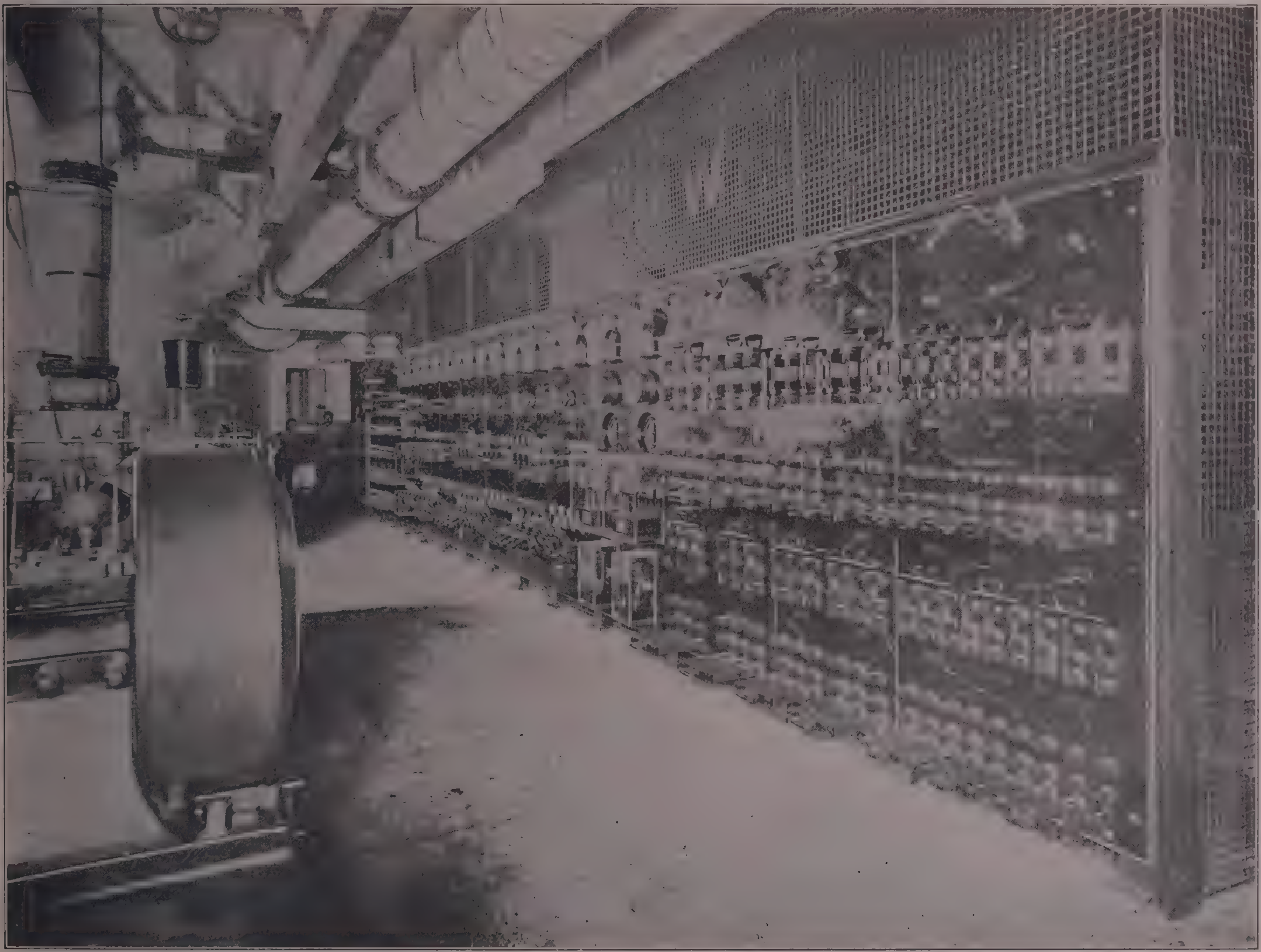
This entire improvement, which required a total of about 1,800,000 lbs. of steel, was erected by 40 men in about 60 days.

The bridge was built for the city of Philadelphia, and its design and construction were directed by Mr. George S. Webster, chief engineer, Bureau of Surveys. It was detailed, manufactured and erected by Lewis F. Shoemaker & Co., Schuylkill Bridge Works, General Offices, Philadelphia, Pennsylvania, works at Pottstown, Pennsylvania.

Rust Joints for heating piping are recommended for permanent green house heating systems by Mr. F. Dye. Before the rust joint is made yarn should be calked firmly into the joint.

Mechanical Plant of the New Wanamaker Store, New York.—III.

Electrical Equipment.—The electrical plant in the new Wanamaker store is one of the largest isolated power equipments installed for the service of a single building, being rated at 1,800 kw. For lighting the new building there are over 1,100 arc lamps and about 6,000 incandescent lamps; there is also a motor connected load of over 400 h.-p. The floor conduit has frequent outlets on every floor permitting telephone, bell and other connections to be made through concealed wiring to any part of the floor with the utmost facility.



Lighting and Power Switchboard, New Wanamaker Store Power Plant, New York.

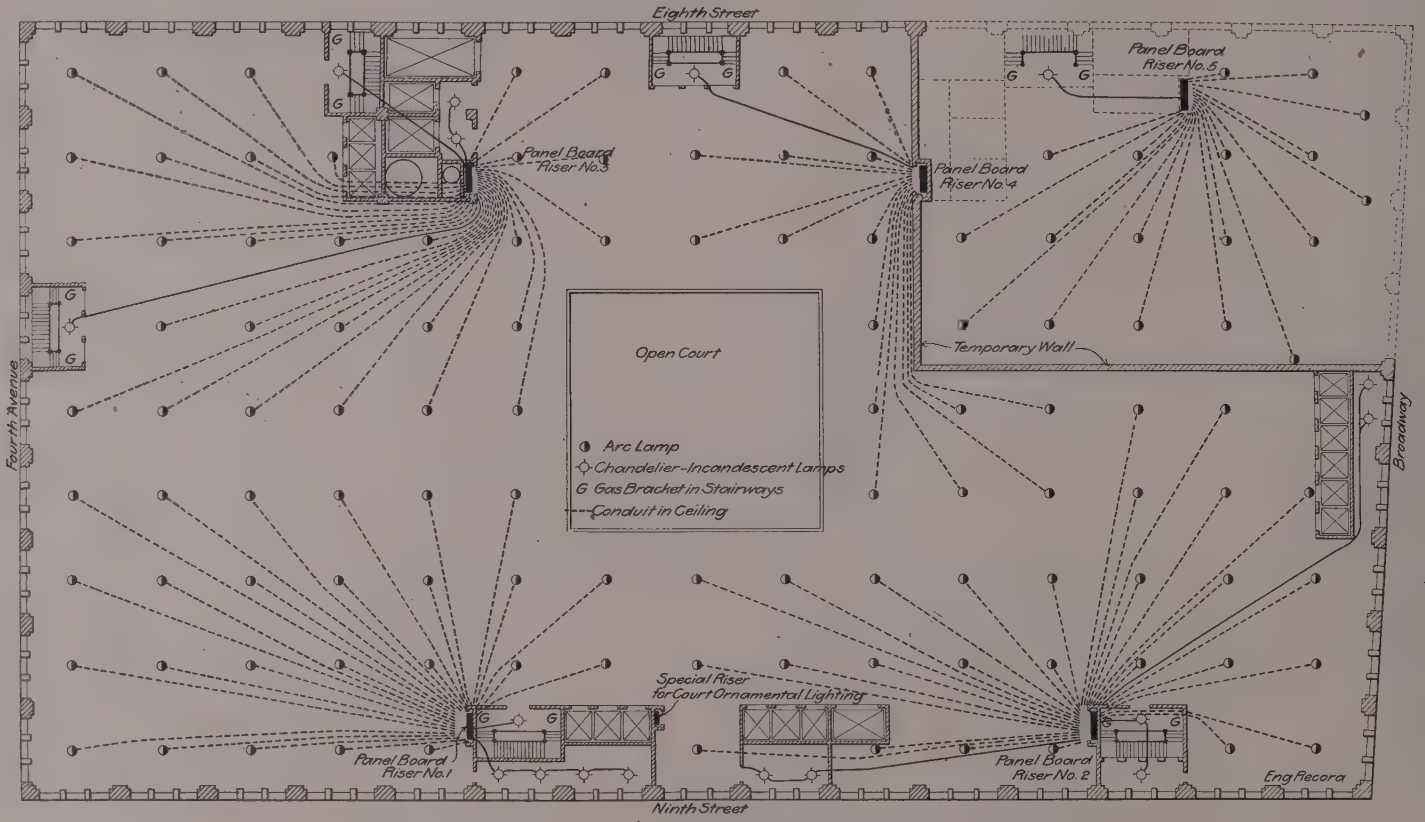
There are six 300-kw. Westinghouse slow-speed dynamos, each direct-connected to a 550-h.-p. Buckeye cross-compound horizontal engine. They are compound-wound generators, delivering at 230 volts, and have special balance coils and auto-transformer equipments to provide the neutral connection for operation on the three-wire system. There are two sets of series coils, one for each side of the three-wire system, and for the neutral lead there are two balance wires connected to the armature winding through ring contacts which lead to two special alternating-current transformers for each generator, back of the switchboard which in turn have a common connection to the neutral lead of the system. These transformers are of small capacity, being designed for 25 per cent. unbalanced load upon the distribution system, which has been very carefully planned for ease of balancing.

The generator and distribution circuits are controlled on a fourteen-panel slate switchboard. Six panels in the middle are devoted to the generators, two for totalizing instruments, and the remainder for feeders. Of the latter, three panels at one end of the board carry feeders for the lighting systems only and three at the other end are devoted to motor feeders. Each generator panel has two ammeters, one for either side of the three-wire system, a field rheostat handle, a voltmeter plug, a four-pole main switch and a four-pole I. T. E. "reversite" circuit breaker, there being four leads from each generator. Two voltmeters are hung on a swinging bracket toward one end of the board in the usual manner, both of which are 250-volt instruments, one permanently connected to the bus-bars, while the other may be cut in on the leads from any generator. The totalizing power panel at the left of the generator section carries two voltmeters, a totalizing ammeter, a 3,000-ampere total recording wattmeter and a testing equipment consisting of an ammeter, a recording wattmeter and a Mabbs selector switch for the ammeters, there being connections permitting these to be thrown on any power feeder leaving the board. The equipment of instruments for the totalizing lighting panel is similar, except that they are duplicated for the three-wire system, all power circuits being run two-wire for operation at 230 volts only, while the lighting circuits are three-wire. The totalizing instruments for the lighting system are of 8,000 amperes capacity for either side of the system.

The power feeder panels contain 31 feeder circuits, four of which are in reserve and one a large trunk feeder leading across the street to the old building, while the lighting system panels contain 14 three-wire feeder circuits, two of which are also trunk-feeders leading across to supply the old store. The arrangement of test switches for each feeder enables any one to be thrown in upon the test instruments upon its totalizing panel. Each feeder switch upon either power or lighting panels is duplicated by a switch of the same capacity immediately below it, which when thrown in and the regular feeder switch opened, connects that particular feeder to the test or recording equipment by which an individual record of current consumption upon it may be kept for any length of time desired. This arrangement is one that is of much value to a commercial plant, as it enables any particular portion of the building to be isolated and examined as to current consumption and resulting cost of operation.

Wiring Scheme.—The electric light wiring of the new building is in five sections, each supplied from a centrally located group of feeder risers, extending vertically from the sub-basement to the attic, with panel-boards on every floor for local distribution. This arrangement is shown in an accompanying typical floor plan of the building, including the section to be completed later at the Broadway and Eighth St. corner. Each of the four risers now in service is intended to supply practically one-quarter of the building as at present built, while the fifth will be located in the corner section to be added later and will supply that portion of the building alone. Each group of risers is located close to the center of distribution of its quarter of the building alongside either a stair well or a pipe shaft to permit convenient panel-board locations.

The panel-board itself is enclosed in a fire-proof sheet-steel casing, while this casing, together with the conduit connections, is located within a spacious closet with double folding doors opening outward. The advantages of this arrangement is that the entire panel-board and its feeder connections are rendered easily accessible, being entirely unconcealed from floor to ceiling, and this entirely without affecting the interior finish of the store. The cables are run exposed in the riser shafts, passing through the floors in special conduit thimbles which are embedded in the concrete, so that there are no openings between floors. The panel-board box is mounted upon a special angle-iron framework in the riser closet, which also has insulator racks for the feeder cables at the rear.



Arrangement of Lighting Circuits for the Typical Floor, New Wanamaker Store.

The feeders in each group of risers are laid out for two centers of distribution, one just below the first floor level, from which all circuits from the sub-basement to the second floor are fed, and the other immediately below the ninth floor, from which all circuits are fed from the third floor to the roof. There are thus two sets of feeders in each riser, each of those for the lower centers of distribution being a single three-wire circuit while each of those for the upper centers has two or more three-wire circuits. These feeders are in all cases very heavy, those supplying the lower centers in riser shafts being 500,000, 1,000,000, 700,000, 500,000 and 1,000,000 circ. mils respectively. The upper centers of shaft 1 have two feeder circuits of 900,000 circ. mils., those of shaft 2, three of 1,000,000 circ. mils.; No. 3, two of 1,000,000 circ. mils; Nos. 4 and 5, two of 800,000 circ. mils. each. The lower centers are in each case located 25 ft. above the engine room level while the upper centers are 150 ft. above. These feeders are carried up in the riser shaft on the panel box frames to the feeding points. From each center of distribution sub-feeders are extended upward and downward through the panel boxes on the various floors which are supplied, there being in general five panel-boards handled from each lower center and twelve from each of the upper centers of distribution. The sub-feeders are in all cases single circuits, most of which are of four 400,000 and 500,000 circ. mils.

These feeder and sub-feeder circuits were all laid out on the three-wire system and have in all cases been installed with all three wires of the same size. All feeders have been designed for a drop of not more than 5 volts from the switchboard to the farthest outlet; the maximum allowable feeder drop is 3 volts, while in all branch circuits 2 volts drop is not exceeded. As the generators deliver 115 volts upon either side of the system, 110-volt lamps may be used at the most remote feeding points. Connections are provided for attaching a portable recording wattmeter to any board and thus recording the current consumption in that section of the floor. The panel-board connections are arranged to permit any circuit being operated on 115 or 230 volts at will by rearranging interchangeable connecting screws between main feed plates and cross branch plates on the panels.

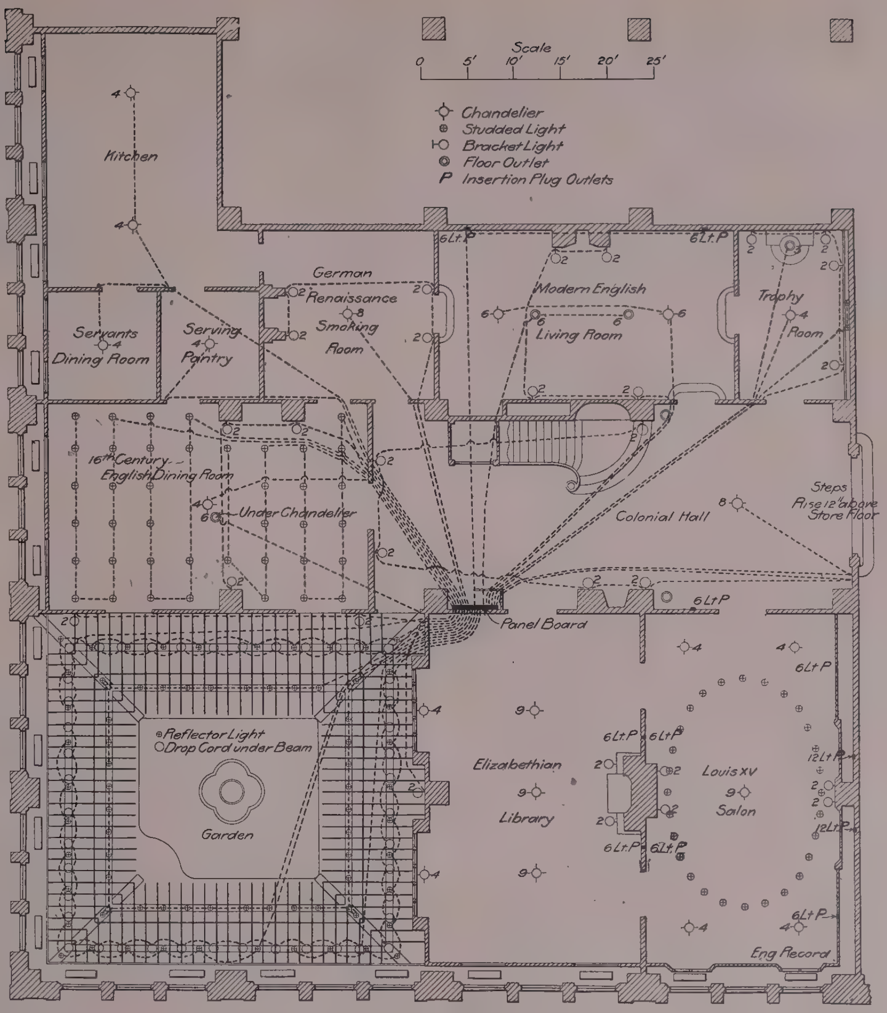
Lighting.—There are from 15 to 25 arc lamps supplied from each panel-board in the riser closets, there being 96 installed upon the average floor of the present building; on the completion of the corner at Broadway and Eighth St., there will be 17 added, making the number per floor 113. The arcs are spaced 20 ft. apart crosswise of the building and 21 ft. longitudinally, each lamp thus covering 420 sq. ft. of floor area; as 1,200-c.-p. lamps are used, there is thus a rate of illumination of about 3 c.-p. per square foot of floor area. There are at present 742 arc lamps in the building; these are, however, confined to certain floors, as none are used on the second, third, fifth, sixth, seventh and ninth floors. There are outlets provided for 1,167 arc lamps, which, when the projected corner is added, will be increased to over 1,400 outlets.

Each arc light is operated on a separate relatively short circuit from the panel-board at its feeder closet, thus making all lamps entirely independent. They are controlled through individual knife switches and enclosed fuses on the panel-boards and are wired up through lines of conduit in the ceiling. These circuits are of No. 14 wire in all cases except where the length is greater than 80 ft. when No. 12 wire is used; they average 60 to 70 ft. in length, the longest being about 120 ft. The arcs are in all cases hung singly upon chandeliers from the ceiling, at uniform heights of 9½ to 10½ ft. above the floor level and midway between lines of building columns. The lamps used are 1,200-c.-p. 6.6-amp. enclosed arc lamps, manufactured by the Stanley-G. I. Electric Mfg. Co., and are operated at 110 volts.

Incandescent lighting will be used on all floors. In the sub-basement 240 outlets have been provided, while in the show windows on the streets and in the Rapid Transit Subway station, in the art gallery and in the music hall, large amounts of concentrated lighting are used with special Frink reflectors, amounting in all to 128 outlets. On the second floor, in the piano show rooms, and also in the "model house" and the music hall, extensive use will be made of ceiling studded lighting, nearly 800 outlets being provided for this purpose. The total number of outlets in the conduit system is 4,824, of which 847 are for chandeliers, 297 for brackets, 777 for studded lamps, 494 for drop cords, 249 for attachment plug boxes, and 222 for floor boxes; the remainder are for switches, arc lamps and other connections. Attachment plug sockets are provided in all elevator shafts at every floor to facilitate shaft lighting.

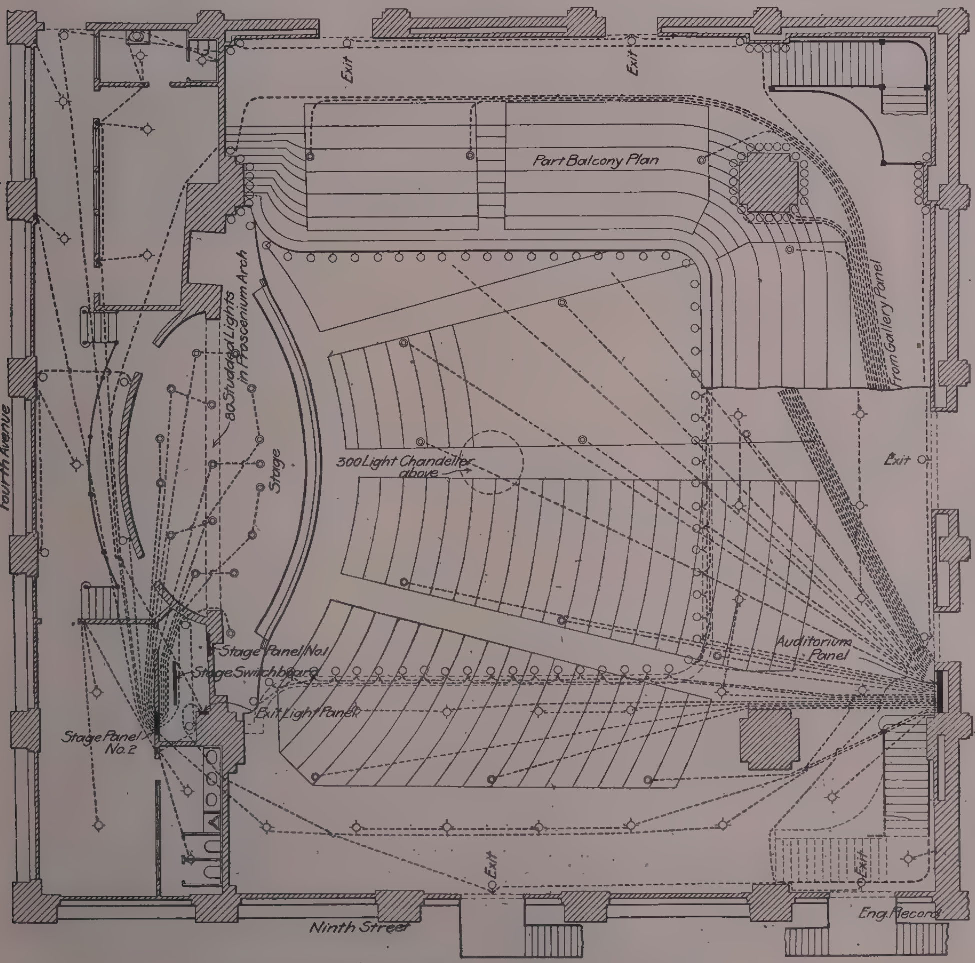
In addition to the general riser system there has been a separate riser group installed alongside one of the elevator enclosures on the Ninth St. side of the floor, from which the ornamental lighting up to the eighth floor in the open court rising through the center of the building is supplied. On this shaft panel-boards are installed at every third floor from which the branches for that and the two adjacent floors are taken. As the court lighting will be used only on the retail floors, above which, at the eighth floor, the court is surmounted by an ornamental skylight to separate it from the service section of the building above, these risers extend only to that floor, there being panel boxes for this service at the second, fifth and eighth floors only.

Model House.—The interior arrangement of the model house, used for demonstrating furniture and decorative materials, is partly indicated by the accompanying first floor plan, which includes a layout of the wiring and conduit work for the lighting scheme. Special lighting effects have been attempted in the salon, the dining room and in the garden. The salon has a domed ceiling of oblong shape, and around its edge there is a row of 28 studded lights. The room has also five chandeliers and four two-light brackets, the center chandelier having nine lights and those at the outside four lights each, all controlled from a bank of nine switches near the door entering the hall. In the dining room there is an arched ceiling in which there are forty studded lights with a four-light chandelier in the center. There are in addition three two-light brackets at the sides and an attachment outlet in the middle of the floor for extension-cord connections to dining table lamps. The garden consists of a porch extending around the four sides of a garden space and fountain in the center, above which are trellis frames for vines, on which the lighting scheme is arranged. This consists of two rows of studded lights, 72 in all, extending entirely around the under side of the trellis framework. The lights are placed in troughs with special reflectors to diffuse a soft light upward and not visible from below. There are in addition 44 lamps hung on single drop cords under the trellis beams for Chinese-lantern garden effects.



Lighting of the Model House, Wanamaker Store.

The lighting of the model house is controlled from a centrally located panel-board in the hall, from which 42 circuits run on the first floor and 15 on the second floor. The circuits are carried in conduits under the floor and above the ceiling throughout, and practically all circuits are controlled through local switches in the various rooms. There are in every room a number of insertion plugs, each of which is of six light capacity, for use in connection with extension-cord lighting for decorative effects. A considerable number of circuits are provided in addition to those shown on the plan, which are intended for future decorative lighting schemes; these are handled from an auxiliary panel-board located beneath the stairway on the first floor, there being 12 circuits supplied from this board. For the supply of current to these panel-boards a three-wire circuit of 300,000 cir. mil cables is used, leading from the nearest point in the No. 1 group of risers.



Model Theater Wiring in the Wanamaker Music Hall.

Music Hall.—The arrangement of lighting and circuits in the music hall is shown in an accompanying drawing. The principal features are a 300-light chandelier in the center of the domed ceiling, a row of 80 studded lights on the proscenium arch, a row of 60 bracket lights around the inner edge of the balcony, and clusters of bracket lights on the four large columns near the corners of the auditorium. For the direct illumination of the stage in case of plays and exhibitions, there is a row of 80 footlights. There are also a large number of bracket lights and small chandeliers for lighting at the sides and rear of the auditorium and balcony, and a large number of floor outlets in all parts of the auditorium floor and the balcony to facilitate special lighting arrangements.

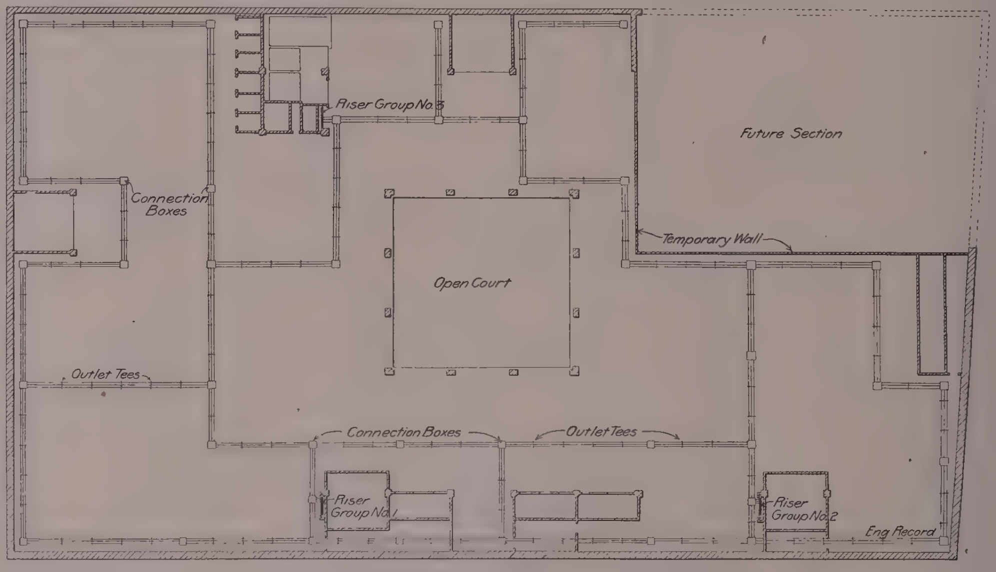
The control of the music hall lighting corresponds very closely with modern methods of theatre lighting, all circuits in the hall being controlled from a large stage switchboard. This board, which is one of the standard dimmer switchboards for variations in intensity of lighting, is located in a room at the right of the stage in which there are two stage panel-boards, from which are wired the footlights, the lighting upon the proscenium arch, the large chandelier, and the floor outlets upon the stage proper. The remainder of the lighting fixtures of the hall is wired from a panel-board at the rear of the auditorium. There is a special panel in the switchboard room devoted to the exit lighting circuits, which was installed independent of the other panels in order to prevent the exit lights being extinguished at any time through mistake or otherwise; there are in all twelve of the exit lights at fire escapes and entrances to the store proper.

The greatest concentration of lighting is in the 300-light chandelier in the center of the auditorium. It is wired for 24 circuits, each consisting of three No. 6 wires in ¾-in. conduit, controlled from the dimmer switchboard. Both the footlights and the proscenium arch lighting are operated on two circuits, each fed by three No. 10 wires in ½-in. conduit. The auditorium and balcony panel boards have 58 three-wire circuits, the general arrangements of which are shown in the accompanying plan. There are two motors required in the music hall, one of 15-h.-p. capacity for a pipe organ to be installed in the space on either side of the stage, and the other a 2-h.-p. motor for echo organ at the rear of the hall.

Floor Conduits.—Under-floor conduits have been installed on all floors for the bell, telephone and signal wiring. The system has outlets at frequent intervals, averaging 10 ft. apart, so that in no case will it be necessary to fish wires more than 25 ft. under the flooring from the nearest outlet point in order to reach any section of a floor. The arrangement of this under-floor conduit system is illustrated in an accompanying plan of the typical floor. It consists of a continuous circuit of conduit work extending from riser groups Nos. 1, 2 and 3 and encircling all sections of the floor.

The conduit system consists of three lines of 1¼-in. loricated conduit laid under the floor with connection boxes at all corners and at intermediate intervals of from 40 to 50 ft. All three lines of conduit are bushed into the connection boxes, which have tight-fitting brass cover plates flush with the surface of the floor and serve as convenient fishing points from which wires may be extended to any outlet point desired. These connection boxes are of cast iron, 9-in. square and owing to their locations are very accessible. It has been found possible to fish through several hundred feet of conduit without disturbance to intervening connection boxes. The service outlets through which connections are extended to telephones, bell calls, and other apparatus consist of tees in all of the three lines of conduit, which are located approximately 10 ft. apart throughout the entire system. From these and the vacant sides of the connection boxes, wiring connections are fished under the floor to any point desired. The tees in the conduit lines are entirely concealed beneath the floor surface, but access to them is provided through removable sections of the flooring above, which may be taken up by the removal of two screws. These tees are normally plugged, but when connections are to be made through them, they are fitted with outlet bushings.

The riser connections for these low-voltage circuits are made through groups of 2-in. conduit risers adjacent to lighting risers Nos. 1, 2 and 3, and located in the same closets with them. These auxiliary risers have at every floor special interconnection panel-boards, through which branch connections to the under-floor conduit systems are made. This system of under-floor conduit is used for all telephone lines within the building, all bell and signal systems, the watchman's time detector system, and the fire alarm signal systems. The arrangement is such, however, that additional low voltage circuits may be added at any time.



Conduit Lines Under Floor for Low Voltage Wiring.

The wiring system of the building was installed throughout in extra heavy loricated conduit, fitted with galvanized couplings, of which conduit over 75 miles were used. The switch and panel-boards were all supplied by the H. Krantz Mfg. Co., some of the panel-boards being of unusual size; a number have over 60 circuits controlled from them, while the average panel has from 30 to 40 circuits. Bossert outlet boxes were used and Hart switches and baseboard plugs, while the floor box outlets were furnished by the Stanley-G. I. Elec. Mfg. Co. Simplex wire was used throughout for the light and power wiring. The entire electrical installation, including the engines and electrical generating equipment referred to in a previous article, was made by the Thompson-Starrett Co., New York. D. H. Burnham & Co., Chicago, Ill., were the architects and engineers of the building.

(To be Continued.)

A Reinforced Concrete Viaduct.

A reinforced concrete viaduct about 375 ft. long has recently been built by Mr. Edmond Coignet to carry a railway into a gas plant in Paris. Most of the spans are 16.6 ft. long and the general width of the structure is 38 ft., although it narrows down at one end to 26 ft. and at the other to 17.6 ft. These narrow parts support two standard-gauge tracks and have three columns in each bent; the wide portion of the viaduct carries four tracks and is supported by four-column bents. Drawings of the structure in "Engineering" show that the columns are 1.31 ft. square, reinforced with a round 0.95-in. steel rod at each corner, with a hooping of annealed wire. There are no cross beams, the heavy flooring taking their place, but the columns are connected longitudinally by girders about 29 in. deep and 9½ in. wide. These have two 0.63-in. round rods 5½ in. apart in their top portion and two 1.69-in. rods similarly spaced in their lower portion, both pairs bound together by annealed wrappings. The floor is 11¼ in. thick and its reinforcement bars are carried through the concrete of the girders. The lower transverse rods are 0.47 in. in diameter and spaced 3.94 in. apart; they are crossed every 5.5 in. by 0.31-in. longitudinal rods. The top reinforcement consists of transverse rods only, one over every third lower transverse rod. The structure was designed for trains consisting of a 50-ton locomotive followed by 30-ton cars, and was built for seven-tenths the lowest tender for a steel structure.

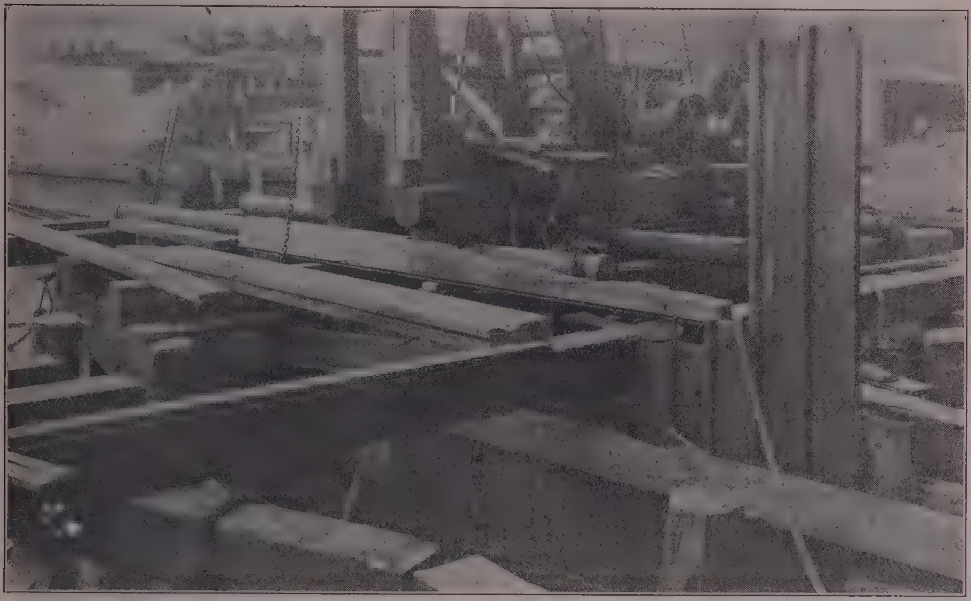
A Steel Sheet Pile Cofferdam for an Intake.

The reconstruction of the Kings County power house at the foot of Gold St., Brooklyn, for the Edison Electric Illuminating Co., involves the building of intake and outlet tunnels for the condensation water. The building has a frontage on the East river, and the tunnels project beyond the outer wall for a distance of about 40 ft. at a clear depth of several feet below low water. Both tunnels are of circular cross-section, except that the invert is flattened, and have an interior diameter of 8 ft. The axes of both are in the same vertical plane, that of the intake being below that of the outlet. Their walls are made with 1:3:5 Helderberg Portland cement concrete which is supported on bearing piles and forms a monolithic rectangular mass about 12 ft. wide, 23½ ft. high over all and 40 ft. long beyond the face of the building, containing both intake and outlet tunnels in the same construction.

The river at this point has an average tide of between 5 and 6 ft. with a moderate current and a low-water depth of about 13 ft. The bottom is of deep soft mud overlying harder strata with rock at a considerable depth. It was determined to build the tunnels in an open cofferdam 12 ft. wide and 42 ft. long, but it was found, owing to the presence of numerous obstructions buried in the mud, especially a rock-filled timber crib, that the construction of an ordinary cofferdam would be very difficult and it was considered by the contractors that it would be impossible to build a wooden pile cofferdam, quite a number of 12-in. round piles having been broken in an unsuccessful attempt to drive them in this place. Some variations being permissible in the position and even in the verticality of the bearing piles, they were driven with difficulty.

Steel sheet piles were adopted for the construction of the cofferdam and the type manufactured by the United States Steel Piling Co. was selected. About 56 tons of piles 30 ft. long were driven to form the three sides of the cofferdam. They were driven with an ordinary pile-driving machine having a 3,000-lb. hammer with which very short blows averaging from 6 in. to 1 ft. were delivered. This method was found more satisfactory than the use of a lighter hammer or a longer drop, and by it the piles were driven under very adverse conditions at a maximum rate of fourteen pieces in eight hours. Their average penetration in the mud was about 9 ft. and they were aligned by their joints and by the use of pairs of inside and outside rangers fastened to round piles, by which they were guided as driven.

Twenty or thirty piles encountered the old submerged crib and were driven through it into the softer material below, displacing the stones and cutting through the timbers, as could easily be observed by noting the effect of the hammer and the sound of the blow. When a pile encountered timber, if the next one beyond it was first driven down clear of the obstruction the preceding one, being furnished with a rigid guide on each side, acted somewhat like a guillotine shear and its comparatively thin web easily cut through the wood. No water jet was used on the work and no effort was made to displace the obstructions except by the penetration of the sheet piles themselves.


Steel Piling Coffer-Dam for the Intake of a Power Station.

In only one case did the piles fail to penetrate to the required depth, two of them evidently encountered a large boulder and refused to be driven farther. Their tops at present project 5 or 6 ft. above the rest of the cofferdam. When the latter is pumped out it is expected that the boulder can be dislodged or cut off and the piles driven down, or that the ground may be found hard enough around it to exclude the water. The piles were all driven with a cap made of a short section of the pile having two web flange plates riveted to its lower end, making guides which held it in place on top of the pile and thus prevented the latter from being battered and upset by the direct blows of the hammer.

The piles have a considerable clearance in the joint which in certain kinds of soil becomes filled with earth, clay or sand so as to make a satisfactory caulking. In this case, however, the mud is so fine and soft and the water above it is so deep that the joints were provided with greased white pine splines inserted before the piles were driven and intended to swell when wet and make a thoroughly tight joint. Each of the outer corners of the cofferdam is made of two pile units having their webs curved at the rolling mill. This enables the corner to be made somewhat more sharply than if turned with regular straight units deflected only by the amounts permitted by the clearance in the joints.

The side walls are tied together at intervals by horizontal transverse screw rods engaging bearing pieces across the tops of the piles on the outside of the cofferdam. As the cofferdam is pumped out, the interior will be braced by the ordinary system of railing pieces and transverse struts. One pile was deflected so much by large stones that it had to be withdrawn and notwithstanding the position in which it was very tightly wedged it was successfully pulled by a six-part tackle operated by the pile-driver hoisting engine. The conditions were such that the contractor considered that a wooden pile could not have been withdrawn. The work is being executed under the general direction of Mr. Chas. H. Carroll, engineer for the Edison Company. The Phoenix Construction & Supply Co. is the contractor, Mr. F. W. Belknap, chief engineer, and Mr. W. T. R. Wilson, superintendent.

A Concrete Water Tower in Italy.

A reinforced concrete water tower which resembles somewhat in its general appearance the structure at Bordentown, N. J., described in this journal on Jan. 13, 1906, has been constructed for the St. Salvi insane asylum near Florence, Italy. The elevated tank has a capacity of 13,200 gal., but this can be doubled without overstraining the tower. The foundation is an hexagonal block of reinforced concrete 20.7 ft. in maximum diameter and 8 in. thick, resting on a gravel foundation 14½ ft. below the ground level. Several feet of very lean concrete are placed as the base and this is covered with earth. From each corner of this base a column is carried up vertically to a reinforced concrete ring at the ground surface. From this ring to the bottom of the tank the tower rises a height of 55.7 ft. The posts of the lowest tier of the tower rake inward somewhat and are 16.4 ft. high; the three remaining tiers are vertical and each is 13.1 ft. high. The tank itself is of the peculiar Intze type, in which the water is confined by inside as well as outside cylindrical walls, making a hollow cylinder, if that term may be used. The outer shell has a diameter of 15.2 ft. and a thickness of 3.15 in., while the inner shell is 2.8 ft. in diameter. The total height of the tank to the roof is 20.3 ft. In designing the structure it was assumed that the most unfavorable condition as respects stability was when the tank was empty and the wind exerted a horizontal pressure of 20½ lb. per sq. ft. on a flat surface and two-thirds of that amount on the plane projection of a cylindrical surface. Under such conditions the steel is subject to a tension of 14,200 lb. per sq. in. and the concrete to one of 425 lb. This tower, which is illustrated in "Beton and Eisen," was designed by Prof. Attilio Muggia.

Special Column and Girder Details in the Office Building of the New York Central Lines.

Although the new office building of the New York Central Lines (Eng. Record, Feb. 24), will at first be completed to a height of only eight stories above the street, it is proportioned throughout for these loads increased by twelve additional stories, which will carry it to an ultimate twenty-story height. The loads developed thus become very great for some of the columns, and in one case reach a maximum of 3,194,600 lb. in the lower stories. To sustain this load, which is believed to be unprecedented for any column in a building, this column is made for a length of about 91½ ft., up to the pipe gallery floor, with three webs, the center one being composed of two plates. This portion of it is built in three lengths with milled butt joints 15 in. above the floor levels, spliced with field-riveted cover plates.

The upper section has a maximum load of 2,510,200 lb., and is made with four 6x4x¾-in. and four 4x4x¾-in. flange angles, four 18x¾-in. web plates, four 24x½-in. and two 24x9/16-in. cover plates. The lower section of the column differs from the top section in that it has six 24x⅝-in. cover plates. The upper two sections of the column have parallel edges and closed cross sections of ordinary construction. The lower section is like them at the upper end, but differs from them in having the cover plates tapered to a width of 4 ft. 8 in. at the bottom, thus providing an extended base long enough to cover the entire width of the grillage beam.

It was calculated that all of the stress at the base of the column would be transmitted through the cover plates and would be reduced to a safe bearing pressure on the upper flanges of the grillage. All interior columns are similarly made with lower sections having three webs, the two outside webs terminating at the pipe gallery floor where they are capped to form horizontal shoulders or seats receiving the bearings of the heavy longitudinal trusses which are thus made entirely independent of field connections and avoid the transmission of the loads through riveted connections.

Above this point the columns are continued with an I-shape cross-section made by an extension of the center web. At the temporary roof the column is calculated for a load of 986,700 lb., due to the future upper stories, and is made with four 6x4x⅝-in. flange angles, two 18x⅝-in. web plates, two 14x½-in. and two 14x⅜-in. cover plates. All interior main columns are made with three webs and tapered cover plates on the lower sections, and are constructed on the same principle.

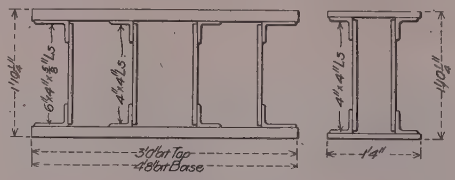
In the Forty-fifth St. front the wall columns have very heavy loads, and up to the post-office floor level are made with four webs, the two outer ones terminating there and supporting double girders between which the center webs are continued to form the standard rectangular cross-section for the upper story lengths.

All other wall columns have, in the basement, ordinary rectangular closed cross-sections made with only two webs and with parallel edges, it being in these cases deemed undesirable to provide them with tapered cover plates in the lower sections. It happened that the feet of some of these columns are located under a platform where they are concealed, and as it was necessary to distribute their loads over only four or five grillage beams they were made with special extended bases as shown in the typical detail. The ¾-in. wing plates extend the 20-in. cover plates to widths of about 3 ft. and 3½ ft. to engage the 4-beam and 5-beam grillages, and so come within reasonable shop dimensions.

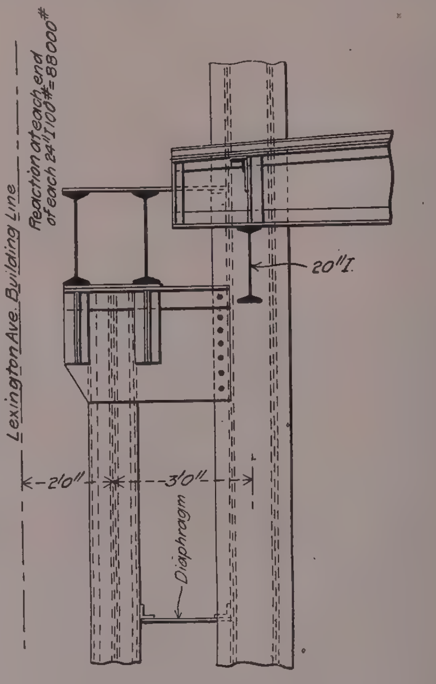
The plates are stiffened with horizontal and vertical reinforcement angles and have 1-in. horizontal base plates. The foot of the column is completely finished in the shops and becomes virtually a pedestal made integral with the column itself.

This style of construction would have been very unsuitable for the seven and nine-beam grillages in that it would have required exceedingly wide, long and heavy wing plates and would have presented a disagreeable appearance in the building. The details of these columns were carefully studied by the designing engineer in conference with the representative of the bridge shops, and it was decided to be much more efficient and economical as well as more pleasing in appearance to make the heavy columns with tapered cover plates, gradually increasing the width throughout the lower story. This avoided the great difficulty and expense of making separate pedestals and securing a finished joint between them and the ends of columns as well as the indispensable one on the grillage beams.

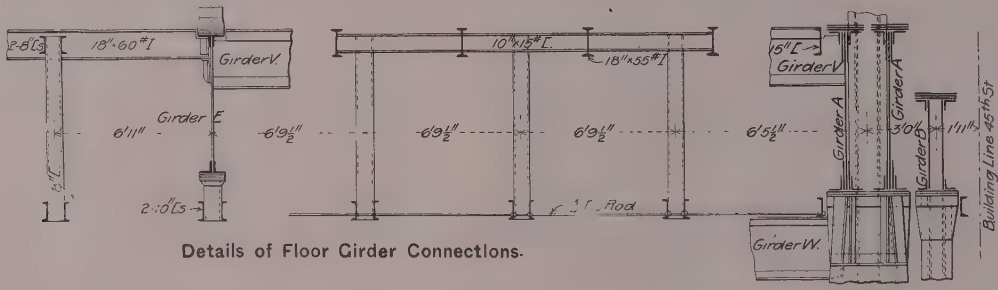
The Lexington Ave. floor above the railroad tracks is supported on longitudinal plate girders 34 in. deep of 20 ft. 9 in. span in lines 44 ft. apart in the rows of the columns. These girders are between and parallel with the tracks so that they clear the cars at a much lower level than they could in any other location. They carry on their top flanges transverse plate girders 34 in. deep, 44 ft. long and 6 ft. 11 in. apart supporting the concrete floors. This construction was adopted for two reasons, first because the longitudinal girders afford opportunities for carrying pipes across the building, and second because the 34-in. transverse girders allowed 6 or 8 in. more clearance for the cars than would have been possible with any other arrangement.



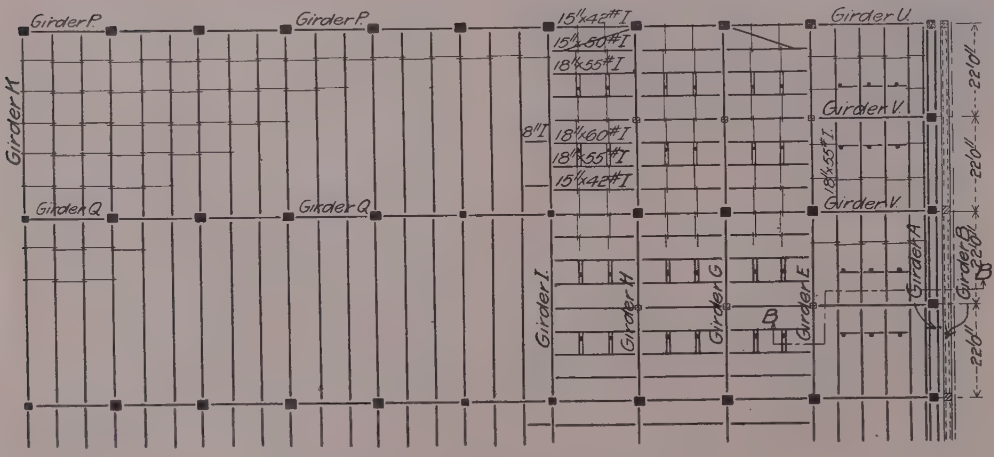
Details of Column.


Lexington Ave. Building Line
Reaction at each end of each 24" I 100# = 88000#
20" I
2'0"
3'0"
Diaphragm

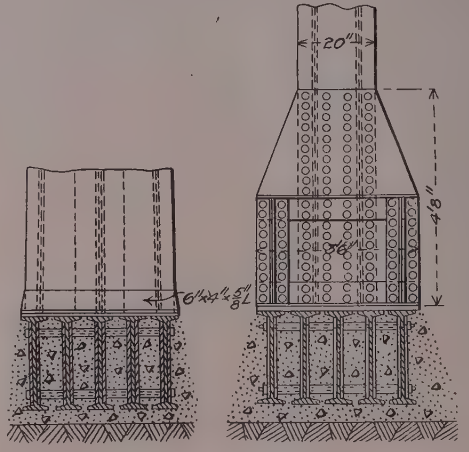
Details of Short Outside Column.



Details of Floor Girder Connections.



Plan Showing Arrangement of Floor Girders.



Typical Column Footing.

On the Forty-fifth St. side of the building the space directly over the main girders is used for a pipe gallery and the main floor of the general delivery post office is elevated about 8 ft. higher to correspond with the floor of the Forty-fifth St. viaduct. The post office floor is carried by longitudinal 15-in. and 18-in. I-beams of 20 ft. 9 in. span supported by transverse plate girders in the column lines except in the panel nearest the street, where there are longitudinal plate girders carrying transverse 18-in. I-beams.

The arrangement of the railroad tracks entering the lower story of the building on the Forty-fifth St. front requires a spacing of 44 ft. between the longitudinal rows of columns. The architectural features of the front and the economical construction of the upper stories require, however, that the columns in the three end transverse panels should be spaced only 22 ft. apart transversely from the level of the general delivery post office floor up, thus necessitating the interpolation at that height of four rows of columns intermediate between those of the lower story. These interior columns are carried on the top flanges of single-web transverse plate girders 72 in. deep as indicated in the cross-section showing the suspended ceiling and pipe gallery floor, which was published Feb. 24.

In the outer walls the columns besides carrying the floors of the eighteen upper stories, carry the fourteen upper stories of the wall masonry. This imposes on them such heavy loads that single girders are inadequate to support them; they are therefore carried on pairs of plate girders supported on the wall columns as indicated in the detail cross-section through them and through the parallel girders that carry independently the wall up to the main cornice at the fourth office floor. Each of these girders is made with an 84x9/16-in. web plate, four 8x8x⅞-in. flange angles, four 16x⅝x8-in. vertical flange web plates, and six 20x11/16-in. flange cover plates, 12, 18 and 44 ft. in length. The girders weigh about 20 tons each, and will be completely shop riveted.

The twin 7-foot girders are seated on the uppers ends of the two inclined outer webs of the lower sections of the wall columns which terminate at this level and thus afford direct bearing for the heavy loads. The upper sections of the columns are composed of the center webs of the lower sections continuing uninterruptedly between the webs of the twin girders. Adjacent to these columns are short outside columns carrying on their caps box girders which support the lower stories of the heavy outer walls, entirely independent of the floor system, so that deflections or temperature movements will not be transmitted from one system to the other or cause any possibility of cracks in the masonry. The wall girders are arranged at different levels so that their upper flanges form horizontal offsets corresponding to the sidewalk grade and varying about 11 ft. in height in the width of the building. It was necessary that the floor girders and wall girders should be separated because the former will not receive their full load until the building is extended to the full height. The fireproofing is arranged so as to be entirely independent for the two girders, but the tops of the outer and inner girders will be connected to each other by diaphragms at column points.

There is suspended from the Lexington Ave. floor an inclined ceiling which conceals the irregularities in level of the floor girders. In four transverse panels at the Forty-fifth Street end of the building, the Lexington Ave. floor becomes the ceiling of a pipe space about 7 ft. high in the clear. At this level there are longitudinal plate girders in the lines of the column rows 44 ft. apart. These carry on their top flanges transverse girders made with pairs of 10x15-in. channels back to back, 8 in. apart. Intermediately these channels are suspended by vertical 8-in. channels riveted between them at intervals of about 15 ft. The horizontal lines of channels are connected by ¾-in. tie rods which secure them against transverse vibration. The lower flanges of the channels receive the flooring for the pipe gallery and metallic lath for the plaster ceiling which is continuous with that in the remainder of this story. The upper ends of the 8-in. suspended channels are riveted across the webs of 8-in. horizontal longitudinal channels that connect the regular 8x18½-in. transverse I-beams in the main floor at the end of the building which serves for the general delivery post office, as shown in the longitudinal elevation and is intermediate between the remainder of the Lexington Ave. floor and the post office floor next above it.

It was considered necessary to make the outer walls on all sides of the building except Depew Place self supported up to the main cornice because the architectural requirement that the lower portion of the building should present the appearance of an enlarged base necessitated the location of the columns to carry the upper stories at a considerable distance inside of the building lines. This brought the columns so far within the inner face of the lower wall that the weight of the latter would have loaded them too eccentrically and they were designed as already stated with independent supports on three sides of the final building. On the Forty-fifth St. front the box girders shown in the detail are 48 in. deep with a ½-in. web, four 6x6¾-in. flange angles and six 22x11/16-in. flange cover plates from 20 to 44 ft. in length. They are seated on the caps of special one-story columns abutting on the center lines.

The successive girders are set at different heights so as to form offsets corresponding approximately to the sidewalk grade which slopes 11 ft. between Lexington Ave. and Depew Place. In some cases the tops of the columns receive short pedestals to provide seats of different heights for the adjacent girders and at one column the lower girder only is seated on the column cap across the full width of which it extends, the other girder having its lower flange seated on a filler block on its top flange. On the Lexington Ave. front the wall is carried at sidewalk level by two lines of 24-in. 100-lb. I-beams seated on the caps of one-story columns 20 ft. 9 in. apart on centers, parallel with and 3 ft. distant from the main wall columns. In the four panels nearest Lexington Ave. these beams are replaced by three lines of 20-in., 65-lb. I-beams carried on brackets that are connected to the outside two-story columns and to the main wall columns. At the corner of Lexington Ave. the one-story column is omitted and the three wall beams are framed to the short cantilever end of the 27-ft. box girders 3 ft. deep which carry the wall in the 45th St. front, as previously described.

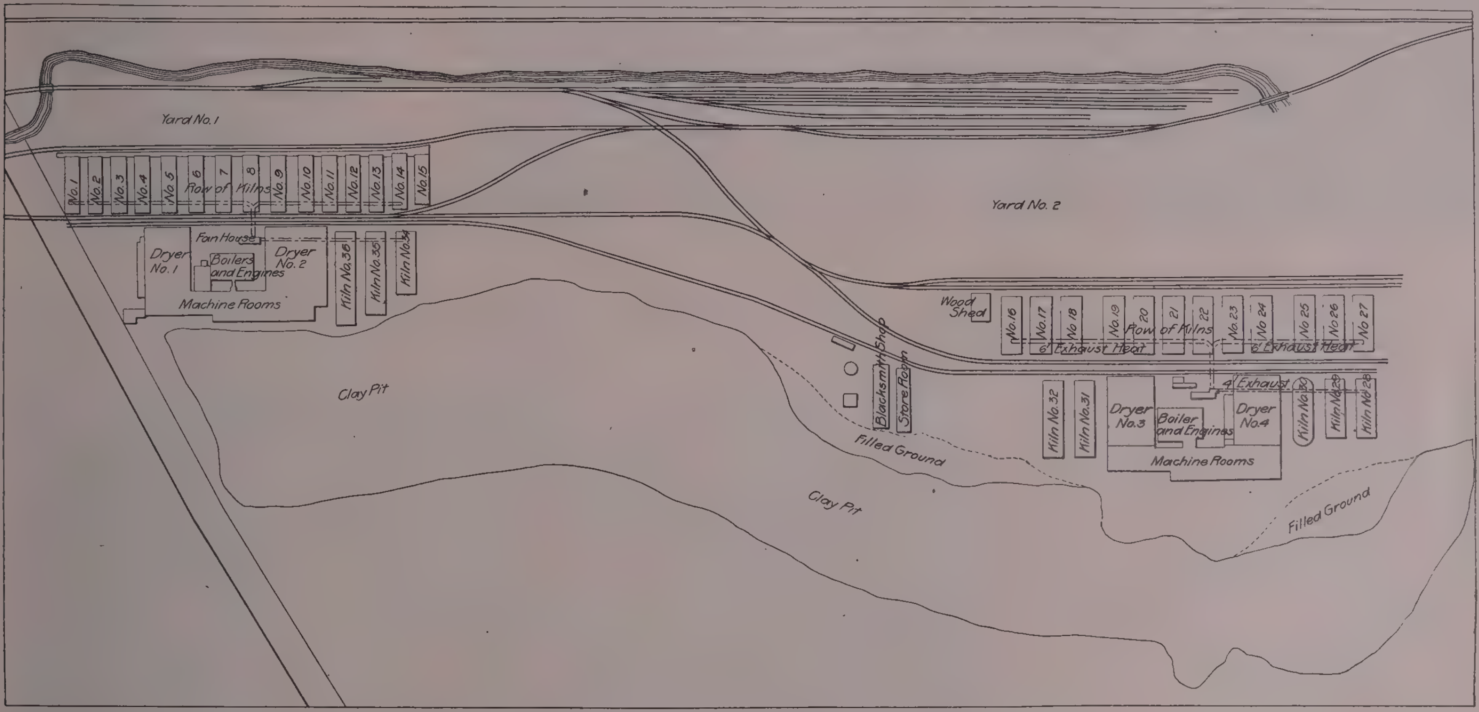
Transporting Contractors' Supplies.

Transporting contractors' supplies by teaming is often a very expensive undertaking and wasteful of time. The attempt to haul heavy loads over poor roads results in cutting up the latter until they are beyond any serviceability. A contractor may have a large amount of narrow-gauge track on the site of this work, which he would not think for a minute of giving up, and yet between this track and the railway station where his materials are delivered he is content to rely on roads almost impassable at many times. The capabilities of narrow gauge railways for hauling materials over long distances are little recognized; the cost of forming and keeping the track for such a line is not very heavy in comparison with the expense of keeping in repair a dirt road for heavy teaming On such narrow-gauge roads there is no reason to be scared by heavy grades. The power plant builders of the Pacific Coast have demonstrated repeatedly the practicability, even in very rough country, of concentrating the heavy grades in a few inclines where rope haulage can be employed. Such a transportation system calls for a greater first outlay than that for teams and a corduroy road, but the total cost of handling materials by it at the close of construction may be considerably less.

The Manufacture of Brick from Shale.

The plant of the Purington Paving Brick Co., at Galesburg, Ill., consists of four separate yards, the combined production of which in 1905 was 86,000,000 brick. Four kinds of brick are manufactured in the yards; paving blocks, repressed paving brick, continental building brick and ordinary building brick, paving blocks having been the chief product of the plant, however, up to the present time. The brick are made from a dense shale, almost rock, which is mined from a hill in the vicinity of the plant. The latter is located along the valley of a small stream on one side of the hill; two of the yards, No. 1 and No. 2, made up the original plant, and the other two, No. 3 and No. 4, were acquired and added to the plant after they had been in operation for some time. The general arrangement of Yards No. 1 and No. 2, which are about 2,000 ft. apart, is shown in one of the accompanying illustrations. This arrangement is much the same as that of the Yards No. 3 and No. 4, which are up the valley 5,000 and 2,000 ft., respectively, from Yard No. 1.

Rectangular, arched-roof down-draft brick kilns are used in all four yards. Yard No. 2 contains 17 of these kilns, placed as shown in the accompanying plan. Twelve of the kilns in this yard are in a row, with two standard-gauge switch tracks from the railroad connection along each side of the row and close to the ends of the kilns. Storage piles are placed beyond the tracks on one side of the row. The remaining kilns, the machinery, dryer and boiler and engine rooms, together with auxiliary buildings are placed immediately across the tracks along the other side of the row of 12 kilns. The face of the shale pit that has been opened up is back of the machinery, dryer and other rooms, and extends over 2,000 ft. from this yard to Yard No. 1.



General Plan Showing Shale Pit and Arrangement of Yards Nos. 1 and 2.

Mining Shale.—The deposit of shale from which the brick are made covers, so far as has been prospected, an area of about 150 acres in the immediate vicinity of these two yards to a depth of 65 to 75 ft. below the ground surface. These yards and the nearest yard to them up the valley, Yard No. 4, are all three supplied with shale from the same pit. The supply for Yard No. 3, which is nearly ¾ mile from Yard No. 1, is obtained from a pit adjacent to that yard. A layer of red clay, 8 to 12 ft. thick, overlies the stratum of shale in the large pit and is wasted by hydraulic sluicing, although it would make fairly good brick. The water for sluicing is obtained from the small stream which flows down the valley, and is forced through a 6-in. spiral-riveted steel pipe, 2,000 ft. long, by an 8x16-in. Gardner pump in the engine room of Yard No. 1. Connections are provided on the 6-in. pipe at convenient distances along the face of the pit. A stream from a ¾-in. nozzle on a 2½-in. hose attached to the 6-in. pipe at one of these connections is used effectively in moving the material. The water pressure at the pump is 160 lb., resulting in a pressure of 120 lb. at the nozzle. The face of the pit is kept nearly vertical and the disintegrated clay at the top loosened by the stream is diverted into open flumes on trestles built up from the bottom of the pit. These flumes are 1 ft. square in cross-section and are built over service tracks and plant, with which work is being carried on at the face of the pit, to a convenient waste area along the bank of the stream.

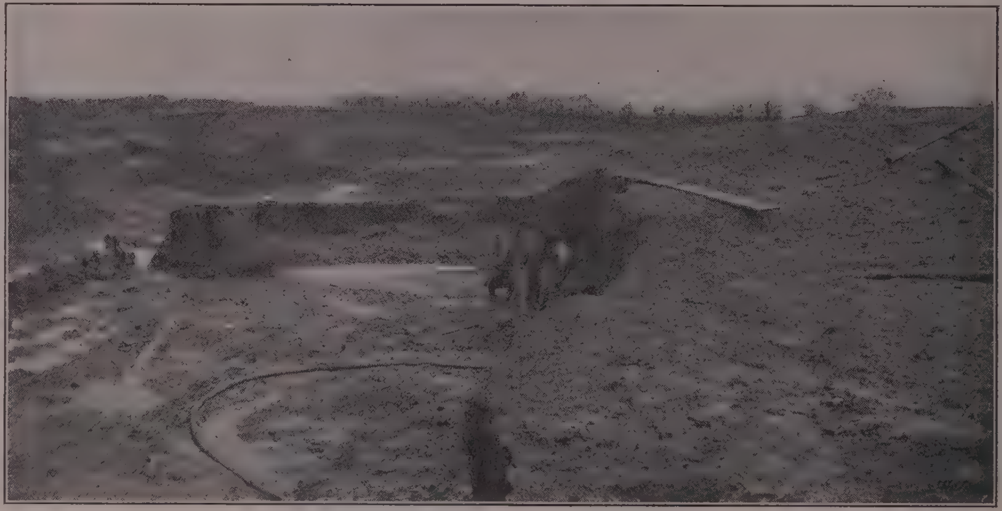
Yard No. 1, with Yard No. 4 in Background.

The present method of working the face of the pit is to first loosen by blasting the top 30 ft. of the 60-ft. stratum of shale below the 8 to 10-ft. surface layer that is wasted by sluicing. A 90-ton Marion steam shovel, with a 3-yd. dipper, then works along the base of the face of the pit, following up the blasts, and loads the loosened material into 2 and 3-yd. dump cars on a service track parallel with the side of the excavation. The cars are handled between the shovel and the foot of a track on an incline at each of the adjacent yards by a small locomotive. The two inclines are about 2,000 ft. apart, and approximately at right angles to the service track along the shovel. This track is 400 to 500 ft. from the base of the inclines, and the shovel is generally between the projected lines of the latter. A specially arranged device for placing the dump cars as they are needed at the shovel enables the one locomotive to handle the cars from the shovel to the foot of the inclines as fast as they can be loaded. An 8-in. x 14-ft. steam cylinder is placed along one side of the floor of the shovel car. A piston in the cylinder, controlled by a lever near those which control the dipper boom, and operated by the man who manipulates the latter, carries a cable with a hook on the end which is attached to the cars and pulls them into place after the locomotive has placed the end car of an empty train of cars within the range of the dipper. A siding is built along the service track near the foot of each incline. The locomotive works between two trains of cars placing an empty train at the shovel and then delivering a train of loaded cars to foot of one incline while the empty train is being loaded. It brings back a second empty train from the siding at the foot of the incline and delivers the newly loaded train to the other incline, the movement being repeated in this manner.

A 105-ton Marion steam shovel will also soon be installed in the pit. The face of the latter will then be worked in two lifts by the two shovels which will advance together. One shovel will cast over the top 30 ft. of shale in one lift; the other shovel will follow closely behind on the bottom of the pit and take the face of the excavation to grade. The 90-ton shovel now at work removes 1,000 cu. yd. in a 10-hr. day under normal conditions, advancing about 24 ft. against the 60-ft. face and cutting a strip 20 ft. wide. The hydraulic sluicing with a single stream from a ¾-in. nozzle easily keeps pace with the shovel progress in removing the overlying 8 to 12 ft. of clay that is wasted.

Operation of Yard No. 2.—The inclines at both yards are built on a grade of about 10 per cent. and are 350 to 400 ft. long. The dump cars loaded with shale are hauled up each of them by a hoisting engine with a 52-in. drum, made by the American Hoist & Derrick Co. The incline at Yard No. 2 enters on approximately the transverse center line of the machinery room and ends on a level platform in the latter. The arrangement of the grinding, mixing and molding machines in this room at that yard is practically symmetrical on both sides of the platform at the end of the incline. A hopper with its top just below the level of the platform is placed on each side of the latter and the shale is dumped from the cars into either of these hoppers. Each hopper discharges into a revolving dry pan, 9 ft. in diameter, in which two vertical 4,400-lb. muller wheels are placed. The crushed shale passes from the dry pan to an inclined belt conveyor which delivers it to shaking inclined 4x20-ft. screens. These screens have oblong 3/16x1-in. meshes and all material refused by them passes back to the dry pan.

The product of the screens is conveyed back to a pug mill mixing machine near the dry pan. The semi-wet process of manufacture is used, sufficient water being introduced in the pug mill to cause the crushed shale to adhere together. The mixture of shale and water is fed from the pug mill into a Chambers brick machine from which a continuous block of pressed clay with the same relative cross-section as the finished brick or block is delivered. This continuous block is discharged from the machine on a horizontal belt conveyer extending from the machine to the end of the room. An automatic machine by which the continuous block is cut on the conveyor in the desired lengths by wire is set about 20 ft. from the brick machine. Placed at proper intervals from this cutter to allow for desirable rates of operating the brick machine and the belt conveyor are five repressing machines made by the American Clay Working Machinery Co. These machines are set in a row at right angles to the line of the belt conveyor, the brick being lifted from the latter to them by hand. The green brick have the corners rounded and the name of the firm stamped on them in one operation by these machines. The machinery on the opposite side of the incline platform is arranged practically in duplicate to the arrangement just described.


Stripping Shale Pit by Hydraulic Sluicing.

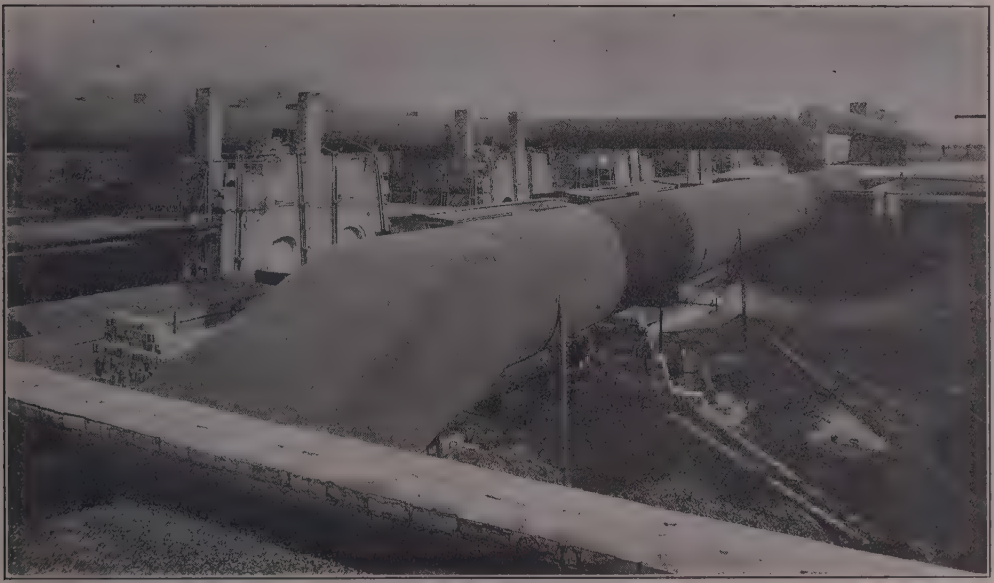
The repressed brick are taken from the repressing machines by hand and placed on narrow-gauge steel-frame cars on four-wheeled trucks. These cars hold 440 brick each and operate on service tracks between the repressing machine and two drying rooms. The drying rooms are back of the machinery room, one toward each end of the latter as shown in the plan. A transfer track extends the length of the machinery room at the rear, and is depressed sufficiently so cars on the service tracks, which are transverse to it, can be run on cars operating on it. On the opposite side of the longitudinal service track from the repressing machine transverse service tracks lead from that track into and through the drying rooms, the entrances being covered by swinging doors. The steel-frame cars loaded with green brick are run on the cars on the transfer track and then shunted to any track leading into the drying rooms. The dryer rooms have brick side-walls and roof. The temperature in them is maintained at 250 to 300 deg. Fahr., and the green brick are generally at this temperature for 24 hours.

The service tracks which pass through the dryer rooms connect at the other end of the latter with another longitudinal transfer track of standard gauge. Between this transfer track and the row of kilns is a standard-gauge switch track which is depressed so the floor of a car on it is level with the floor of the kilns. The cars of brick from the dryer rooms are run on cars on the transfer track, hauled in line with the kiln being charged and then run across the depressed switch track on a portable bridge and into the doors of the kiln. Those kilns on the opposite side of the switch track from the row of 12 are also supplied from the standard-gauge transfer track.

The average time of burning is 9 days, Illinois bituminous coal being used in the furnaces along the side of the kilns. When the burning has been stopped, the brick are annealed for five days before the kiln is opened. The burned brick are then removed through doors in both ends of the kiln and loaded in cars for shipment or stored for future delivery. The heat thrown off by the brick during the annealing process is utilized in the drying rooms. After the firing of a kiln has ceased, the dampers are closed in its furnace flues. A damper is then opened in a connection between the kiln and a 6-ft. exhaust duct leading to the drying rooms. This exhaust duct is 600 ft. long and extends overhead the length of the row of kilns. The heat from the kilns on the other side of the switch track is also drawn into the drying rooms. A 160-in. fan, made by the American Blower Co., in a house between the drying rooms and back of the machinery rooms, induces a draft in these ducts and forces the heated air from the kilns through the drying rooms. The waste heat from the kilns is sufficient to supply the dryer rooms when the plant is in operation.

Arrangement of Yard No. 1.—Fifteen of the 18 kilns at Yard No. 1 are in a single row, as shown, and have railroad tracks on both sides arranged the same as those at Yard No. 2. The general arrangement of the machinery and dryer rooms and the method of operation is also much the same as in that yard. Only one crusher, one mixer, one brick machine and one set of repressers are used, however, in operating this yard. These are in one wing of the machinery room. The other wing of that room contains a crushing and screening plant in which the shale is prepared for Yard No. 4. The incline leading to this yard from the shale pit enters the machinery room on its transverse center line, and cars on it dump into hoppers arranged the same as those in Yard No. 2. These hoppers supply the crushing plants in each wing. The shale prepared in this plant for Yard No. 4 is hauled to the latter in Atlas 3-yd. steel dump cars.

Yard No. 2 from Shale Pit, Showing Incline from the Latter at Right.



Overhead Ducts for Conveying Waste Heat from Kilns to Fan House.

Power Plants.—The power required to operate the machinery is supplied from a central plant in each yard. These plants are placed, in each case, in boiler and engine rooms just back of the machinery room and between the drying rooms. The various machines in each machinery room are driven from a line shaft which extends the length of the latter and is belted to the fly-wheel of a main engine. The plant at Yard No. 2 contains four 72-in.x18-ft. horizontal tubular boilers made by the Frost Manufacturing Co. and fitted with McClave steam jet grates, and a Corliss engine. The plant at Yard No. 1 contains three of the 72-in.x18-ft. Frost tubular boilers and a 225-h.-p. Hamilton Corliss engine. A 22-kw. Western Electric generator, placed in the engine room, supplies power for lighting three of the yards and for operating machines in a repair shop. The Gardner pump which supplies water for the hydraudic sluicing is also placed in the engine room. The equipment of the power plants at the other two yards is much the same as that of those just described.

Repair Shop.—A 24x100-ft. brick blacksmith and repair shop is located near Yard No. 2. The machines and tools in this shop are of sufficient size and capacity that practically all maintenance repairs on the equipment of the yards are made in it. The repairs required in the yards are excessive, the kilns alone necessitating an expenditure of $50,000 a year to keep them in serviceable condition. The character of the materials handled also causes excessive wear on the machinery and other equipment in the yards, the maintenance expenses of this part of the plant exceeding $50,000 a year.

Water Supply and Fire Protection.—The water for hydraulic sluicing is drawn from the small stream which flows through the plant. The water supply at Yards No. 1 and No. 2 is obtained from a lake covering 7 acres to a depth of 22 ft., which is approximately 1,000 ft. from Yard No. 1 and furnishes a 14-ft. head at the engine room floors. The supply for Yard No. 3 is drawn from another large artificial lake, and that of Yard No. 4 from a reservoir supplied by the small stream. A system of 6-in. water mains with fire hydrants at suitable intervals is supplied with water under a pressure of 160 lb. by the Gardner pump in the power plant of Yard No. 1. The company carries its own insurance. The woodwork in the yards is all being replaced by steel, concrete and brick construction, so that the fire risk can eventually be practically eliminated.

Transportation Facilities.—The 86,000,000 brick produced by the plant in 1905 were largely shipped to 8 or 9 of the surrounding States. The company has considerable business, however, in all parts of the country, having supplied paving brick in large quantities to cities as far away as Atlanta, Ga. It was also recently awarded a contract by the United States government for 3,000,000 brick for pavements in the city of Panama. In 1905 9,228 cars were required to handle the product of the plant, 4,325 cars to furnish the coal supply, and 236 cars for other purposes. A switching connection is made between the tracks at the different yards and the lines of the Burlington R. R. system in Galesburg. All of the lines of this system which traverse Illinois, except the one from Chicago to Minneapolis, pass through Galesburg, giving an excellent outlet to the plant for the bulk of its business. The main line tracks of the Atchison, Topeka & Santa Fe Ry. pass within a few hundred feet of the yards, and switching connections are also made wtih this railroad.

The operation of the plant is under direct supervision of Mr. W. S. Purington, vice-president and general manager of the Purington Paving Brick Co.

The Importance of Railway Water Supplies is well shown by a section of the annual report recently made by Pres. Cassatt of the Pennsylvania R. R. Owing to the largely increased demand arising from the growth of traffic, he states, the former sources of water supply had become inadequate, and on the lines traversing the coal districts the quality of the water was rapidly becoming unfit for locomotive use. Arrangements have now been made, through contracts with companies organized and owned by the company, to secure an adequate supply of good water at all points on the main line between Pittsburg and New York, and also on the more important branches, and for the construction of the reservoirs and the piping of the water to the lines, whence it will be distributed along the right-of-way to the necessary points. The cost of this undertaking will be large, but it will be of incalculable value, while the difficulty in obtaining water in sufficient quantity and of good quality shows that this step could not have been longer delayed. It is proposed to obtain the funds for this outlay by an issue of special securities maturing at short periods, and as there will be a large saving both in cost of water and in boiler repairs, the principal and interest can be met, without undue burden, out of current income. Bonds for part of this work are now being sold.

Construction of the Title Guarantee and Trust Company Building, New York.

The steel cage fireproof office building for the Title Guarantee and Trust Co., New York, has a front of 75 ft. on lower Broadway and occupies the whole of a lot 135 ft. deep. The roof is about 126 ft. above the curb and it has a nominal height of six stories, but as these include six regular stories and four mezzanine stories and it has a basement and sub-basement below the street level, it provides 12 floors, counting the pipe floor in the top of the building. It is made with hollow tile floors and partitions and the steel framework is of very simple construction, having 27 columns arranged about 18 ft. apart in four longitudinal rows about 18 ft. and 25 ft. apart. The columns have closed rectangular sections made with two channels and two cover plates and all of them are seated singly or in pairs on double or triple-web plate girders which distribute their loads across the grillages formed of I-beams 18 or 24 in. in depth.

The grillage beams are arranged in groups of from 10 to 29, which form footings of a maximum size of about 23x26 ft.

The largest footing supports four columns, one at each corner; most of the others support two columns except in the boiler pit where the distributing girders are essentially cantilevers carrying two columns and supported by a separate grillage at each end. The combined area of the grillages somewhat exceeds one-half of the area of the lot and the beams are seated on concrete beds which are continuous across the full width of the buiding between the grillages at the Broadway end, but do not extend beyond the limits of the I-beams in the remainder of the building where the excavation is not so deep.

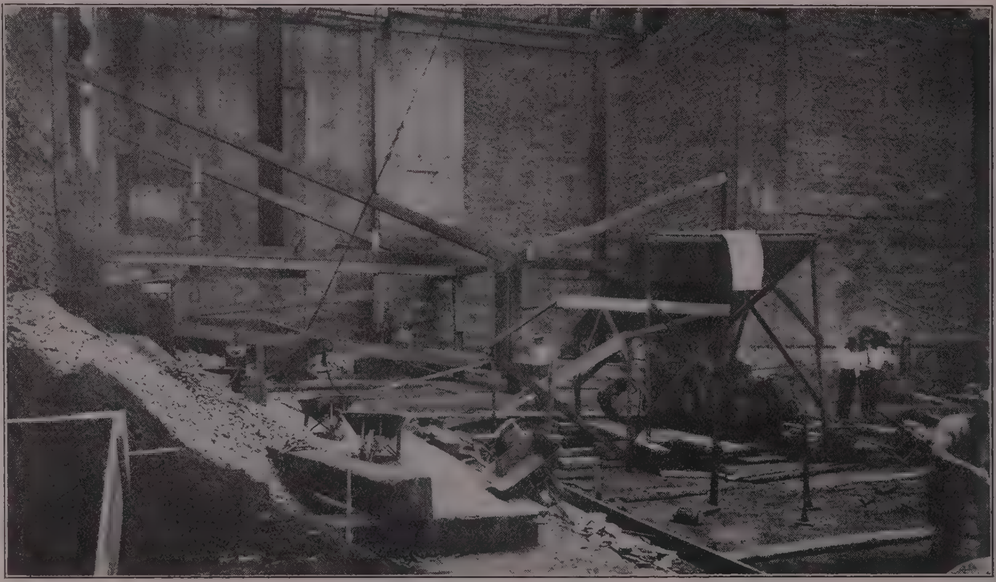
The old buildings previously occupying the site were removed down to street level by a wrecking contractor and the remainder of the debris was removed by the general contractor. The old cellar floor was at a level of about 8 ft. below the curb and the general excavation of the pit was carried 17 ft. farther down, ground level being 1 ft. above this height. At the Broadway end of the building a 50x75-ft. area across the full width of the building was excavated to a total depth of 31 ft. to provide additional room for the boiler pit and coal-storage vaults.

The footings of the adjacent 10 and 12-story buildings extend down to about the same level as those of the main part of the new buildings, and are seated there on the natural soil which consists of fine sharp sand containing some clay, but without gravel or boulders. The excavation was carried down to water line in the usual manner inside retaining walls made with ordinary 3-in. wooden sheet piling. The spoil was shoveled into 1½-yd. Stuebner buckets on cars on lines of 24-in. industrial tracks purchased from Mr. Arthur Koppel. These tracks were laid as required, over all parts of the bottom of the pit and terminated at their rear ends with switches and Y branches which enabled an empty bucket to be filled while the full car was switched by it, and run to the Broadway end of the lot where the bucket was hoisted by a derrick seated in the pit and having a 70-ft. mast and a 62-ft. boom 24 in. in diameter.

This derrick was guyed with eight 1½-in. steel ropes, was rigged with seven-part hoisting and topping lift tackles rove with ¾-in. plough steel lines, and had a capacity of 20 tons. The buckets were dumped into two bins on platforms over the sidewalk bridges where there was a total storage capacity of about 30 cu. yds. The bins were provided with the chutes and gates through which they delivered beyond the curb line into wagons in the street. These enabled the excavation to be continued regardless of ordinary irregularities in the teaming and also enabled the nine teams to be kept constantly busy regardless of slight interruptions to the excavation.

The sidewalk bridge was of a special design which provided for the convenient extension of its posts and afforded great rigidity for the loads which it carried, amounting at one time when stone was stored on it to over 140 tons which it sustained without danger. The bridge and platform was supported on vertical posts 13 ft. apart longitudinally and 17 ft. apart transversely. Each post was 18 in. square over all, made up with four 6x6-in. timbers, one in each corner bolted together with 6-in. separators on all sides. This gave a stiffness and column strength greater than that of a 12x12-in. solid timber of equal sectional area. It also provided just space enough between the inner faces of the timbers to receive a pair of 3x12-in. diagonal braces, one in each direction, which were secured by a single through bolt and which braced the tops of the post in both directions.

The braces in a plane parallel with the Broadway curb formed a complete truss about 10 ft. deep and added greatly to the stiffness of the structure. The columns were seated at first on the old cellar floor and as the excavation was extended below them their feet were successively supported on long sills until the pit was ready to receive a new footing when the columns were extended by splicing additional corner pieces to their lower ends, the joints being staggered and the construction of the column facilitating excellent splices. The two posts forming each transverse bent of the bridge were connected just above the water-proof roof protecting the sidewalk, by horizontal pieces which with the inclined pieces forming the sloping bottom of the storage bins served to make complete transverse trusses. The platform above the hopper bottom bins was 20 ft. wide and had a floor of 3-in. planks carried by 3x9-in. longitudinal stringers 16 ft. apart on centers.



View toward Rear of Excavation Showing Hoisting Engine and Shoring.

When the bridge was erected the outside row of posts were supposedly set on the retaining wall of the sidewalk vault. It was found later that the wall was not at the curb line as had been supposed, but was somewhat inside of it, so that the posts were really supported on the earth outside of the wall. This, of course, permitted them to settle slightly when the excavation was made and gave the appearance of deflection to the bridge above. As the latter was very heavily loaded at the time some fears were unnecessarily entertained for its safety and 12x12-in. vertical posts were placed under it to remove these apprehensions. It was considered, however, that they were unnecessary and that the longitudinal trusses already mentioned would have amply sufficed to carry the load across the two panels of the structure even if the intermediate bent of the vertical posts had been entirely disabled.

As the bottom of the pit in the main part of the building was carried down 1 ft. below ground water level special provision was required for excavating the last foot. This was done in alternate squares of 10 ft. Rectanguar frames were made with 2x12-in. planks 10 ft. long, set edgewise, and driven down into the sand while the latter was excavated inside them by as many men as could find room to work there. Sometimes the water entered these small shallow pits quite rapidly and was pumped out by hand with diaphragm pumps, at other times very little water entered. As soon as the squares were excavated they were rapidly filled to a depth of 12 in. with concrete mixed very dry by hand and prepared in readiness on adjacent platforms.

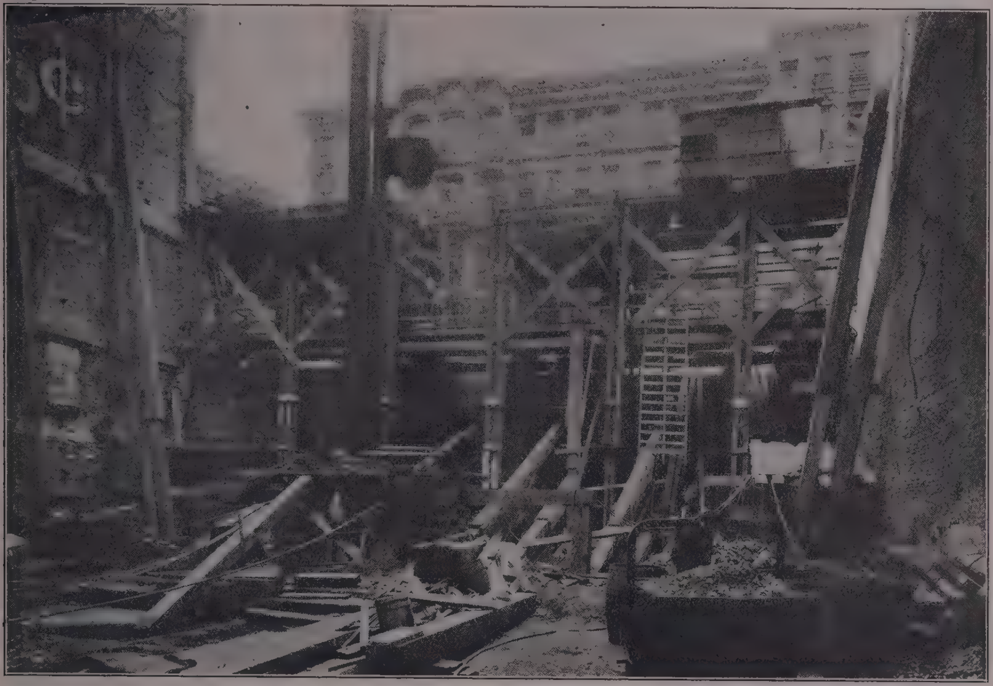
When the spaces between the original alternate squares were excavated the open sides were closed by similar 12-in. planks driven down and the planks remaining on the sides of the concrete already in position were driven down about 6 in. deeper to prevent the possibility of undermining the concrete in position by the new excavation. After the new concrete was in position and before it had set the partition planks were pulled out allowing the new concrete to close up against the old and entirely fill the vacant space. Work was never ceased on any one of these pits after it was commenced until it was completely concreted. The whole of the main part of the excavation was thus concreted in about two weeks, working 18 hrs. daily.

As the excavation for the boiler room and coal-storage vaults was to be made several feet deeper than the footings of the adjacent heavy buildings, and as it was deemed inadvisable to underpin them, it was determined to confine the sand under them so thoroughly that no undermining could take place and to execute the work by ordinary methods with great care. To accomplish this, this portion of the site was first enclosed on all four sides by walls of permanent steel sheet piles of the Friestedt interlocking channel type with units made of Z-bars and 15-in. channels 15 ft. long which were driven to their full length before excavation was made below ground water line, as described in The Engineering Record of October 21, 1905.

These sheet piles were first driven in a row across the pit on the side opposite to the Broadway curb and then served as a heel against which diagonal struts were placed to brace the wooden sheeting driven adjacent to the sidewalk vault which served as a retaining wall. This sheeting had four tiers of 12x12-in. struts 8 ft. apart horizontally. At the ends of the retaining wall the struts were set at an agle to serve as knee braces and took bearing against the side walls of the adjacent building.

The depressed pit contains four sets of grillages, one adjacent to each side wall and two equi-distant intermediate sets, all of them reaching across the full width of the pit perpendicular to the Broadway line. Each set in reality consists of a pair of separate grillages which have only a short clearance between the adjacent ends of their I-beams and are substantially like a single grillage about 32 ft. long. Each pair of grillages was treated as a single one and those at the sides of the lot were first put down. Each of them was made with eight successive pits about 9 ft. wide and 4 ft. long.

The first pit was started at one corner and was excavated inside a coffer dam composed of 2x9-in. tongue and groove planks 13 ft. long. This sheeting was driven by a 350-lb. hammer working in a special portable frame conveniently handled by four men. The frame consisted of a pair of 6x6-in. leads 16 ft. high separated about 2 in. in the clear and braced by a pair of 2x6-in. inclined planks to the tail of a pair of 6x6-in. transverse sill pieces. A sheave was set between the leads with its axis on top of them and a line was run over it to the drum of a Lidgerwood electric hoisting engine. From the other end of the line was suspended the hammer which had a horizontal bolt passing through it and between the vertical leads and engaging a nut and washer which slid up and down on the rear faces of the leads and kept the hammer in position.



View toward Broadway Showing Derrick, Sidewalk Bridge and Shoring for Buildings.

After operations were commenced in the excavation of the 4x9 pit they were maintained continuously, sometimes as much as 35 hrs., until the excavation was completed and the bottom was covered with 1:2:4 concrete made with Lehigh Portland cement and 1½-in. broken stone. Concrete laid above water level was proportioned 1:2½:5. During the excavation pumping was avoided as much as possible for fear of causing a flow of sand and water under the lower edge of the steel sheeting and thereby undermining the foundations of the adjacent buildings in case the equilibrium of subsurface pressure was much disturbed. The men consequently excavated the sand as much as 18 in. below the surface of the water in the pit and all water which was pumped out of the coffer dam was discharged over its side into the bottom of the adjacent pit so as not to remove any of the total weight of the materials in the excavation.

Buckets containing about ½ yd. more concrete than was estimated to be required in the bottom of the pit were waiting in readiness for the moment that the excavation should be completed and their contents were put in as quickly as possible and the pit filled up to subgrade. The successive sections of the excavation for different pairs of grillages were made in the same way and the wooden sheeting between them was cut off at the level of the concrete. The pits were excavated at the rate of about 2½ days for each separate grillage or 20 days in all for the eight grillages.

The wooden sheet piles extended several feet below the bottom of the concrete and the latter was first laid to a thickness of 12 in. and then covered with 2 in. of cement on which canvas was spread and carried up some distance on all four sides of the coffer dam where it was temporarily nailed. On this canvas a sufficient quantity of earth was back filled to balance the upward pressure of the water and hold the footing securely in place until the concrete was well set. After about four days the earth was removed and the canvas stripped off, showing the upper surface of the concrete corrugated with small irregular swellings which indicated the pressure that had been exerted upon it, but were not injurious.

The surface of the concrete was waterproofed with seven-ply of felt and tar which was flashed up the sides of the coffer dam for 12 in. On the waterproofing was placed a pan 14 in. deep made of 20-oz. copper. The bottom of this pan was covered with seven-ply waterproofing protected with 1 in. of cement mortar. On this was laid 4 in. of concrete leveled off 1½ in. below the bottom flanges of the grillage beams.

Across each end of the excavation there was then built a concrete screed 2 in. wide on top and 1½ in. high providing transverse supports for the ends of the grillage beams. The tops of these screeds were very accurately leveled so that when they were two days old and the grillage beams were seated on them the latter needed no farther adjustment. After the grillage beams were set, 2 in. of 1:1 Portand cement was poured into the excavation filling the space up to ½ in. over the bottom of the girder flanges. Afterwards the spaces between the beam webs were filled in the usual way with concrete.

After setting the sets of grillages on the sides of the lot, the excavations were made for the intermediate sets, the grillages were placed in them, the steel work was carried up to the fourth story, and part of the masonry was built on it so as to load the ground heavily and prevent any possibility of material flowing in from any of the adjacent foundations, before excavation was commenced between the grillages. When this latter excavation was completed concrete was laid on the bottom, up to the level of the waterproofing under the grillages. The vertical flashing of copper and felt which surrounded the sets of grillages was then bent down horizontally to lay smoothly on the top of the new concrete adjacent to it and the surfaces of the latter were thoroughly waterproofed with seven-ply felt and tar as before described and the sides of the pit were flashed up with the same to 15 ft. below curb level and protected by the brick wall and an extérior brick facing, thus insuring thorough waterproofing under conditions so difficult that before this method was adopted, the subcontractor was unwilling to guarantee success.

The building contains about 1,200 tons of steel fabricated at the Berlin plant of The American Bridge Company. It was delivered by trucks on the Broadway side and was handled by the derrick already described and by another guyed derrick of 10 tons capacity with a 60-ft. boom which, together with a stiff-leg derrick and a jinniwink derrick, was moved from story to story as the erection progressed. The large derrick was not moved from its original position, but while there it was used to unload and set in place the heavy distributing girders on the grillage beams. The largest of these was about 5 ft. deep and 22 ft. long, had three webs, weighed 18 tons and was handled with ease and safety by the boom at long radius. This derrick set all of the steel up to the street level except what was handled by the stiff-leg derrick in the rear of the lot which served the area not commanded by the main boom.

The steel work was rapidly assembled, 2 stories, weighing together about 110 tons, being erected each week. All rivets were hand driven. The side and rear walls were built up about three stories behind the erection of the steel work, but the front wall being of granite was more slowly built. All of the derricks were operated by Lidgerwood double-drum two-spool hoisting engines driven by General Electric dynamos. Two more single-drum engines and dynamos of the same make were provided for operating the brick hoists. No steam power was used anywhere in the building and the two centrifugal pumps used in the pits were both operated by General Electric dynamos.

An average force of about 450 men was employed and worked single eight-hour shifts daily. Excavation was commenced in the last of June, erection of the steel work was commenced October 15, and was completed December 5. But for delays occasioned by strikes the building would have been now ready for occupancy.

Messrs. Howells & Stokes are the architects. Purdy & Henderson are the consulting engineers for the structural steel work, and the Thompson-Starrett Company are the general contractors. Mr. George Simpson, chief engineer and Mr. C. S. Neal, superintendent. The Foundation Company was the subcontractor for the steel sheet piling, and Mr. H. T. Baker was the subcontractor for removing the old building.

The Nineteenth District Sewerage System in Scranton.

On Jan. 8 of this year the nineteenth district sewerage system of Scranton, Pa., was completed, after being under construction since Nov. 8, 1902. This district has an area of 405 acres, and the sewers which have been constructed to serve it comprise 3,110 ft. of double-ring circular brick sections from 33 to 63 in. in diameter, 2,700 ft. of double-ring brick egg-shaped sections from 2x3 ft. to 2 ft. 11 in. by 4 ft. 4½ in., 4,130 ft. of 20 to 30-in. vitrified pipe lines, 52,940 ft. of 8 to 18-in. vitrified pipe lines, and 1,760-ft. of tunnel sewer, making a total of 64,640 ft. There were also 26,100 ft. of 6-in. vitrified pipe house connections put in at the same time. The average depth of the trench was 11 ft. and the excavation was 30 per cent. in earth and 70 per cent. in hard sandstone. There are 364 manholes, 5 tunnel manholes, 98 side basins and 67 corner basins on the system, which discharges by means of two large outlets into the Lackawanna River.

Trenching Machine Employed on the Scranton Sewerage System.

The contract price for this work was $2.77¾ per linear foot. This price includes the furnishing of all materials entering into the construction of the work and the necessary labor and tools. The laying of the house connections to the curb line on streets and avenues and to the fence line on alleys and courts was a part of the work. The price also included the pay of two inspectors at $2.50 a day each. The cost of the work assessed to the abutting property owners was $131,889.70 and the city's share was $47,647.34, making a total of $179,537.04.

The tunnel before mentioned was driven mainly through rock, but coal and clay were also encountered; its average depth was 40 ft. The rock was very hard and much difficulty was experienced in removing the water, which came through the overlying strata. Through the clay it was necessary to line the tunnel with a double ring of vitrified paving brick laid in Portland cement mortar, but through the rock a V-shaped invert of concrete was constructed.

Above the level of the tunnel a 12-in. sanitary sewer was laid parallel to and in line with the tunnel to take the drainage from the abutting houses and laterals. It discharged into the tunnel sewer through five wells or drop manholes.

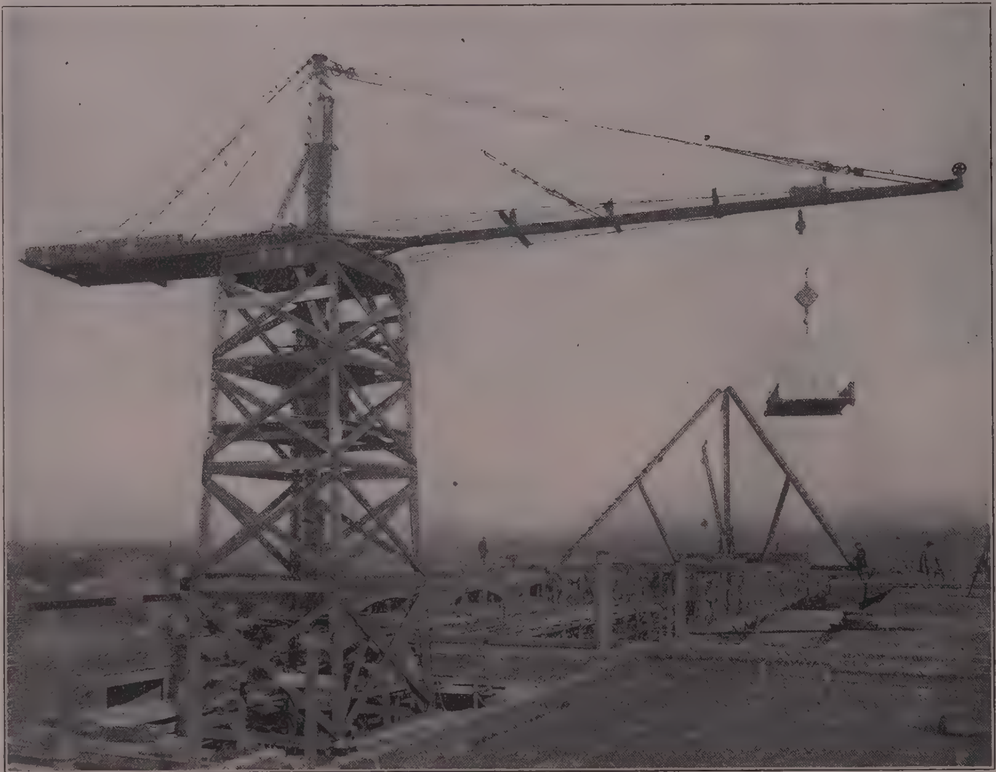
The contractors, Messrs. Ruch & Miller, of Philadelphia, used an overhead carrier above the trench to convey the excavated material to be used as back-filling, thus avoiding one handling of the spoil. All the work was done under the personal supervision of Mr. Henry Jifkins, city engineer, and Mr. James B. Smith, assistant engineer.

By Signing the Bill exempting the Panama Canal laborers from the operations of the eight-hour labor law, President Roosevelt has removed a serious difficulty that stood in the way of the economical prosecution of the work. It has been the unanimous testimony of all who have investigated labor conditions on the Isthmus that the eight-hour law was wholly unnecessary for the canal undertaking. The laborers must come from a class to whom such a provision is entirely unknown and meaningless. They expect to work under the conditions which have been found best for tropical construction, and the attempt to introduce other working conditions, unsuited for the climate and the laborers, has proved so thoroughly unsatisfactory that its abandonment was praiseworthy.

A Revolving Tower Derrick for Erecting Buildings.

A large derrick now in use for the construction of the War College, Washington, D. C., is of a novel type, which was designed by the contractor for this work and has been advantageously used by him for several other important contracts. The derrick is a large self-contained tool constructed to handle heavy loads with ease and rapidity over all parts of the circular area described by its boom, excepting the small space covered by its own base. It is a balanced revolving double cantilever with no outside guys, and is arranged to revolve in a complete horizontal circle and to traverse its load radially. It can be made of any required height and reach and is therefore especially well adapted for location in the center of a structure and to handle the upper part of the work without interfering with the lower portions.

The particular derrick here illustrated is now rented of the owner and builder by Captain John Steven Sewell, Corps of Engineers, U. S. A., in charge of the War College construction. Although a home-made affair, built of timber, it is quite competent to do its work and illustrates the principles which have been carefully developed and executed in steel construction by the designer and patentee, Mr. James L. Parsons, Washington, D. C. It consists of a counterbalanced revolving T-derrick with the mast seated in a framed wooden tower guyed or anchored at its four corners. On this work the principal service of the derrick is in handling masonry, concrete and general building materials, but on other contracts derricks of the same type have been used for setting structural steel work and handling earth and debris as well as for general building purposes.

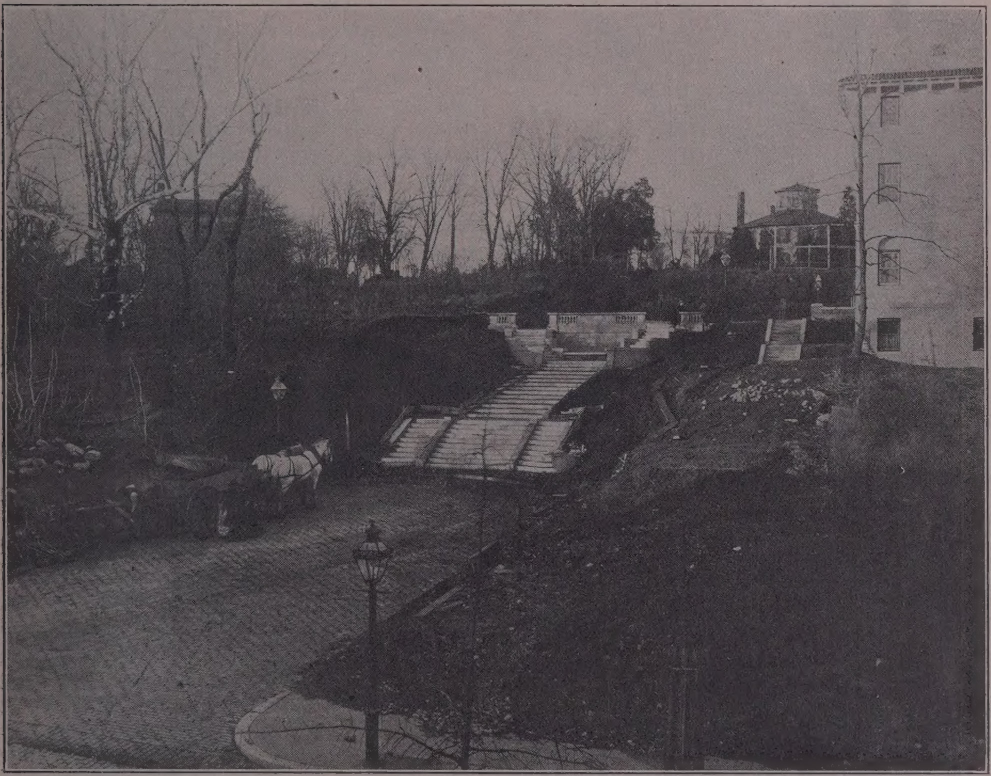


A New Type of Boom Derrick.

The first derrick of this type was designed by Mr. Parsons about 3 years ago as the result of necessity for a tool which would take down an old six-story building on a crowded Washington corner. The structure was so dilapidated that great care was necessary to prevent its collapse and it was considered essential to remove it by an independent derrick which could handle the upper part of the building and lower materials to the ground without danger of developing any stresses in the old structure. Ordinary derricks could not be advantageously employed and the special type here shown was devised to meet the requirements of the case.

Holes 14 ft. square were cut through the floors in the center of the building and in the space thus provided a wooden tower 75 ft. high was erected and secured at the corners by vertical guys, which are essentially simple anchors. A mast and cross piece were then arranged from portions of boom derricks and the machine afterwards used at the War College was constructed and served to quickly and easily take down the building, the boom having sufficient length and capacity to lower the materials beyond the outer walls to wagons in the street.

It proved so satisfactory that it was adopted for the erection of the new building and for that purpose was raised on jackscrews and its height increased to 100 ft. Afterwards the same derrick and a similar one made with a combination of wood and steel was used for the construction of the Marlborough apartment house, a bakery building, and Secretary Hay's Stoneleigh Court, an apartment house. Since then two more have been built entirely of steel and are now being used for the erection of the Municipal Building, Washington.



A Concrete Terrace in Washington, D. C.

The steel frame derrick has a four-sided pyramidal riveted tower preferably about 30 ft. high. It is provided with bearings at the bottom and top for a vertical mast which projects for a good proportion of its length and carries an unequal-armed horizontal cross piece guyed at the ends and intermediately to the top of the mast. The long arm of the cross piece serves as the boom and has a track for the trolley hoist which is operated back and forth by the hoisting line and by a tail line extending to the outer end of the boom. The short arm of the cross piece is provided with a platform for counterweights to balance the loads hoisted.

At each corner of the base of the tower there is a long vertical screw rod so connected to the tower and to the loose base plate under the foot of the inclined post, that it can be screwed down and elevate the tower from story to story as the work progresses. The vertical rods are X-braced in each of the four faces of the tower by struts which slip freely over them with sleeve connections, but can be clamped in position below the tower to provide stability for it when elevated on the screws.

The mast is of massive construction made with a closed rectangular cross-section tapered from the middle to both ends and stiffened by an interior diagonal diaphragm forming a continuous web for the entire length of the mast. Both ends of the mast have forged or cast caps, the lower one being provided with an annular groove revolving on the fixed base. Where the mast passes through the solid horizontal plate forming the top of the tower it is provided with a large bearing ring which keeps it in alignment and transmits horizontal thrust to the tower. The mast is proportioned to have a moment of flexure sufficient to resist bending stresses developed by maximum loads.

The boom is made with a pair of channels spaced far enough apart to receive between them the hoisting tackle carried by a trolley having wheels flanged to engage both sides of the track channels and prevent them from spreading. The channels are also connected by arch yokes, clearing the trolley and are braced horizontally by outside trussing. The boom is virtually continued on the opposite side of the mast by the counterweight platform. It is rigidly attached to the mast and both are revolved through a complete horizontal circle by ropes engaging a bull-wheel attached to the mast just above the top of the tower and led, together with the hoisting tackle, to the foot of the mast and thence through its axis in the usual way to the hoisting engine which may be located at any convenient place. The boom cannot be revolved in a vertical plane and is guyed at the point and intermediately by steel ropes rove like tackles around the sheaves attached to the top of the mast and to yokes on the boom thus equalizing their stresses. The ends of these ropes are fixed and they are adjusted by means of turnbuckles. The end of the counterweight platform is similary guyed by steel rods with turnbuckle adjustments. Turnbuckles are also provided in the main tension rods trussing the boom in the horizontal plane. The derrick is operated by an ordinary hoisting engine with double-drum slewing device.

A Washington Terrace.

A few weeks ago there was printed in this journal a description of the novel system of terraces devised by Mr. Wm. Barclay Parsons for some of the steep streets of San Francisco. The accompanying illustration shows the treatment of a somewhat similar hillside street problem recently worked out in Washington by Mr. George Oakley Totten, Jr., architect, and Mr. W. J. Douglass, engineer of bridges, under the direction of Col. J. Biddle, Capt. J. J. Morrow and C. B. Hunt, engineer of highways. This is on 22d St. W., between S. St. N. and Decatur St. This street is 90 ft. wide and 195 ft. long on the building line. In this length of 195 ft. there is a rise of about 25 ft. and to overcome it the street has been laid out in three sections. The carriageway of the lower cross street is carried up 22d St. for a distance of 82 ft., measured on the curb, and a width of 32 ft. The grade in this distance is about 7 per cent., and at the top the curb ends in a semicircle, connecting both sides of the street. In the same way a similar blind carriageway runs down from the higher cross street for a distance of 82 ft., the grade being about 5 per cent. Between the ends of these carriageways there is no road, but the terrace shown in the picture enables pedestrians to pass from one level to the other. The terrace is of attractive form and the fountain at the top, with its stone balustrade is not only of artistic value but also serves to concentrate in one place the only steep steps necessary in the whole slope.

The total length of the terrace is about 77 ft. Beginning at the bottom, ten steps lead up to a landing a little more than 4 ft. wide. The central steps are 10 ft. wide, then comes on each side a raised curb 10 in. wide, and then steps 4 ft. wide; outside these steps are main curbs 12 in. wide and projecting about a foot above the earth. The second flight, having eleven steps, is much longer, and each riser has a short platform of paving brick behind it. In place of flights of paved steps at either side are terraced flower beds retained by granolithic curbs. The top landing is 4 ft. wide and paved with vitrified brick. The stone is all granite, set in concrete.

The crowning feature, the fountain, has a diameter of 7 ft. outside the rim of its lower basin, and the ten steps surrounding it on either side rise 5 ft. 2 in. The three basins of the fountain are constructed of reinforced concrete.

A LABOR EXCLUSION BILL which has been under discussion in the Maryland legislature is intended to restrict contractors for public works to employing registered voters so long as there are any without employment. This bill is merely an expression of the old, deep-rooted feeling that in purchasing materials or engaging help for public works local interests should be highly favored. It should be borne in mind, however, that if the price of such materials or the rate of wages are higher than those obtained in the open market, the taxpayers of the city are assessed for the benefit of a comparatively small class. Moreover, in any large undertaking like the Baltimore sewerage work, at which the bill seems to be aimed particularly, the difficulty of securing local labor of an efficient and experienced class for many parts of the work would not only delay the time of completion of the construction but would also raise its cost an indefinite but high percentage, where there are plenty of shiftless local laborers who would have to be carried on the pay rolls.

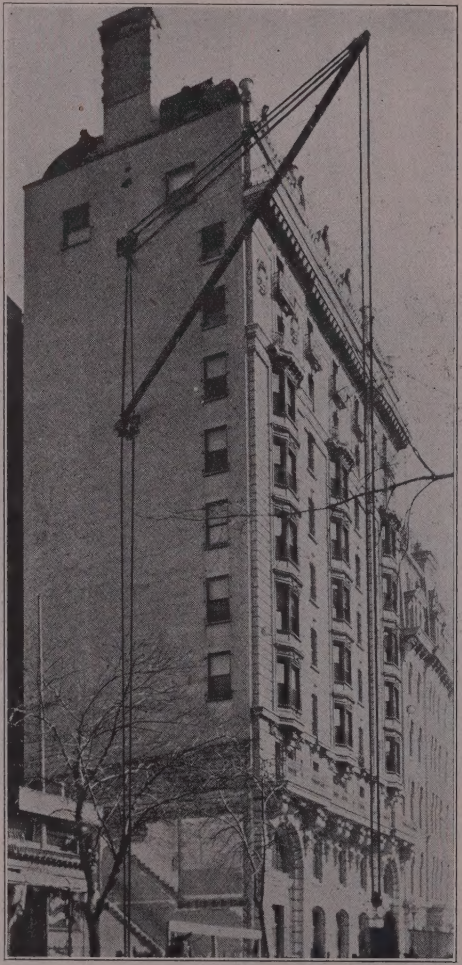
Book Notes.

A little book on "Link Motions, Valves and Valve Setting" has been prepared by Mr. F. H. Colvin, the author of a number of popular books on locomotive topics. The greater part of its contents is devoted to the link motion which is described with the aid of numerous diagrams, and after mastering this description and the suggestions for setting valves, a workman should have little trouble in most problems of this sort that come to him, either with slide or piston valves. Brief notes are also given on the Joy, Walschaert, Allan and other gears. (New York, Derry-Collard Co., 50 cents.)

A second edition of the late Col. W. M. Patton's "Practical Treatise on Foundations" has appeared, which contains a considerable quantity of additional information culled from the technical press. The original book was a good example of an industrious and careful compilation of data on foundations by an engineer with many years' experience in such work. As he pointed out in his preface, foundations offer a greater opportunity for the exercise of a trained judgment than for the play of theoretical analysis, and consequently most of the text was devoted to descriptions of the methods adopted in the execution of large and small foundation undertakings, mainly for bridges and retaining walls, although other classes of structures were mentioned to a limited extent. Nevertheless the author did not omit theoretical subjects entirely and explained the derivation of a number of formulas for retaining walls, piles and the like. The book attained a deserved popularity among engineers as well as students, and the additional information in the new edition should continue its favor among them. It might also be pointed out that the data concerning the cost of numerous foundations should interest contractors. (New York, John Wiley & Sons, cloth, $5.00.)

No engineer and architect who has noted the fluctuations in the price of timber during the last six years needs to be told that economy in the use of wood is absolutely essential if its cost is to be kept within reason. In this country the forest areas are still so extensive that no serious pinch is felt, but in England it is necessary to import annually an amount of wood equal to 2½ times the total timber production from the 23,475,000 acres of carefully tended forest lands of France. There is no natural product that deserves more attention than timber at the present time, as is clearly pointed out in the preface to Dr. J. Beauverie's "Le Bois," a thorough two-volume treatise on all aspects of the subject. In it the growth of trees, their insect and vegetable enemies, the effect of their external conditions on their wood, the principles of silviculture and forestry, lumbering, milling and the sale of the finished products are all treated with sufficient completeness to give the reader a good general knowledge of the present problems of timber production. The material in the book has all been drawn from British and European sources, and unfortunately represents a view of the subject far beyond that held in reckless America, which is cutting down her rich forest lands with the careless abandon of a child slashing down the wayside weeds with a stick. Dr. Beauverie's book, in spite of its size, is a good one to show the folly of this course and the measures that should be adopted to conserve the existing forests and grow more. (Paris, Gauthier-Villars, 20 francs.)

In a little volume entitled "The Nile in 1904" Sir William Willcocks has brought together in concise form the leading data given in Sir Wm. Garstin's report on the basin of the upper Nile and the information gathered by himself during his many years residence in Egypt. Until this book appeared there was no reference book furnishing an accurate and concise statement of the known facts concerning the Nile, and as the development of Egypt is ultimately connected with utilization of the Nile waters in irrigation, the book has already taken a high position as an important work in an economical sense. From an engineering point of view the work is still more interesting as explaining the author's views concerning the works to be built for storing and delivering the river waters. He agrees with Sir Wm. Garstin that the construction of a dam at the outlet of Lake Albert is an essential work, the key to the whole subject of the improvement of the upper Nile. Both these engineers agree further that a channel must be formed through the swamps of the Sudd region, but Sir Wm. Willcocks believes that a new reservoir should be constructed in the Wady Rayan without waiting for the completion of the Sudd channel, while Sir Wm. Garstin considers that this reservoir can wait until the other work is well advanced. The raising of the Assuan dam as soon as the existing conditions have been improved so as to make it feasible is also recommended, and it is interesting to learn that both experts now agree that the Assuan reservoir and that in the Wady Rayan can be worked so as to supplement each other and overcome the old objection that the Wady Rayan project gives least water at the season when water is most needed from it. Some useful data are also given concerning irrigation in the Sudan. (New York, Spon & Chamberlain.)



A Washington Derrick Support.

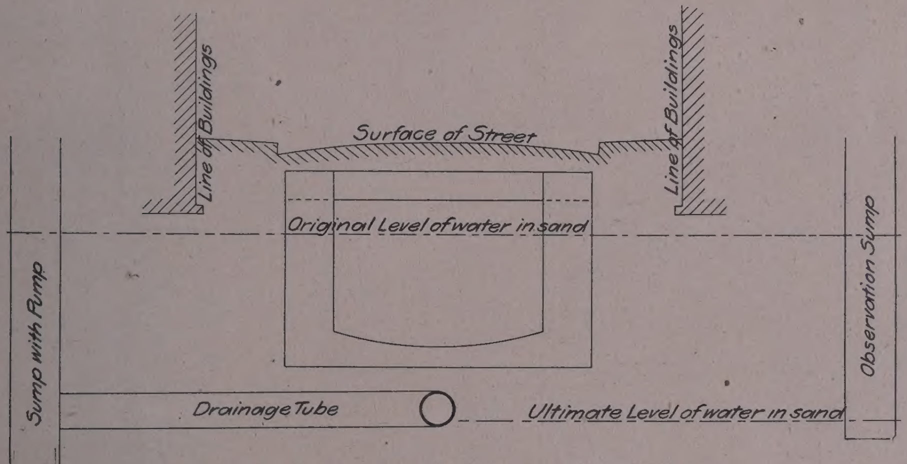
The series of articles on the "Business of Contracting," which Mr. Ernest McCullough has been contributing to "The Contractor" has been republished in pamphlet form and will probably prove interesting reading to many contractors. The author discusses in turn the staff, the foreman, bidding on work, some features of bidding, working method, the office on the work, and field and office methods. It is apparent that most of his experience has been acquired west of the Alleghenies, for he lays considerable stress on the advantages of business methods in the management of contracting affairs that have long been followed in the East. There is, in fact, an interesting difference seen in the East and elsewhere in general contracting. Outside of the North Atlantic States contractors are generally men who have worked up from the shovel or the trowel, but in that section it is not infrequently the case that the head of a contracting business is a man who personally knows very little about the methods of actually carrying on the work; such affairs he leaves to his engineer, superintendent and foreman, taking care to get good men on whom he can rely, while his personal attention is paid to the financial end of the business. Under such conditions the business methods of contracting have been developed until they resemble those of a well organized industrial establishment, and the head of the company knows all the time just what each class of work is costing, where he is getting ahead of his time schedule and where he is falling behind, and other things of a similar essential nature. Mr. McCullough's pamphlet is of value as indicating the ways in which such a business system can be introduced into contracting undertakings of a small size. (Chicago, Technical Book Agency, 50 cents.)

Steam Turbines. By Carl C. Thomas. New York, John Wiley & Sons; cloth, 6x9 in., 297 pages.

American readers will find in the work on steam turbines by Prof. Carl C. Thomas, who holds the chair of marine engineering at Sibley College, an explanation of the fundamental principles of turbine operation and their application in machines now on the market. It is also of interest to more experienced engineers on account of the discussion of such subjects as the velocity of steam flow from a theoretical standpoint and in the light of experiment. At the present time practice is ahead of theory in some branches of the subject, and the author brings out very clearly a number of features deserving investigation. His main purpose has been to analyze and correlate the results of important experimental investigations and show how they can be used in connection with the laws of hydraulics and thermodynamics in studying steam turbine problems.

In the first chapter the author discusses the general action of steam on turbine buckets. While the intricate mathematical analyses given in some books by foreign authors are omitted in the treatment of the subject by Prof. Thomas, this is really an advantage to most readers, who have neither the time nor the inclination to delve deeply into the physical laws of imperfect gases. On the other hand the book explains clearly the fundamental principles of reaction and impulse turbines, the action of steam on vanes, the work done by the steam acting against the vane, and the efficiency of the impulse turbine. In the second chapter the thermodynamic principles involved in the flow of steam are explained, and in the third the graphical representation of the work done in heat transformations is described. The author lays special importance on the heat (temperature-entropy) diagram, although he points out that it is incomplete as a representation of the work done in such transformations and must be supplemented by the pressure-volume diagram. The book is accompanied by a large chart, from which the absolute temperatures for any absolute pressures may be readily found, and also the specific volume of dry steam or steam containing a known amount of moisture. The text and chart should prove useful to readers who have experienced some trouble in mastering computations involving entropy.

With the fourth chapter what may be called the experimental features of steam flow are taken up, the first subject being the calculation of the velocity of flow and the weight of steam delivered. The experimental data of the flow through orifices are summarized in tables and diagrams and some useful approximate methods of calculation are given. The nature of the reaction of a steam jet flowing from an orifice is particularly well described. In the fifth chapter the effect of frictional resistance is considered, and various problems are discussed, several examples being solved to show the successive steps. In the sixth chapter there is a review of experimental work on the flow of steam through orifices, nozzles and turbine buckets. The data have been drawn from many sources and include considerable information hitherto unpublished on such important topics as the weight of steam flowing through nozzles of varying size under different initial pressures, the actual velocity of the jet from the nozzles, the impulse of the jet on buckets having various angles of entrance and exit, the effect of bucket spacing on the impulse, the effect of the clearance between the nozzle and the buckets on the impulse, the effect on the impulse of placing a varying number of rows of stationary buckets in front of a set of movable buckets, the effect of the clearance between rows of buckets on the impulse, a comparison of the impulse of air and steam on buckets, the effect of "cutting over" the edges of the bucket by the jet from the nozzle, and the relative efficiency of rough and smooth bucket surfaces.



Draining Running Sand on the Line of the Glasgow Subways.

The portion of the book relating to the principles of turbine design and operation begins with chapter seven on the impulse turbine, where the details of the Curtis turbine are discussed. The impulse-and-reaction type is similarly discussed in chapter eight. In the ninth chapter the distinctive features of the De Laval, Parsons and Curtis types are pointed out and the results of numerous tests are tabulated. The final chapter is on the marine steam turbine.

The book will probably prove useful to a wide circle of readers on account of its experimental rather than theoretical nature. American engineers generally prefer to rely on experiments rather than on mathematics for their working rules and data, and experimental information is the characteristic feature of this volume. It is in need of careful editorial revision, however, for the mistakes in it are very confusing at times. For example, on page 107 the reader is referred to Fig. 25 for an illustration of some experimental apparatus. This figure is thirty pages back and is a pressure-volume diagram. A diligent search will finally show the desired illustration on page 140, where it has no figure number to connect it in any way with the text on page 107.

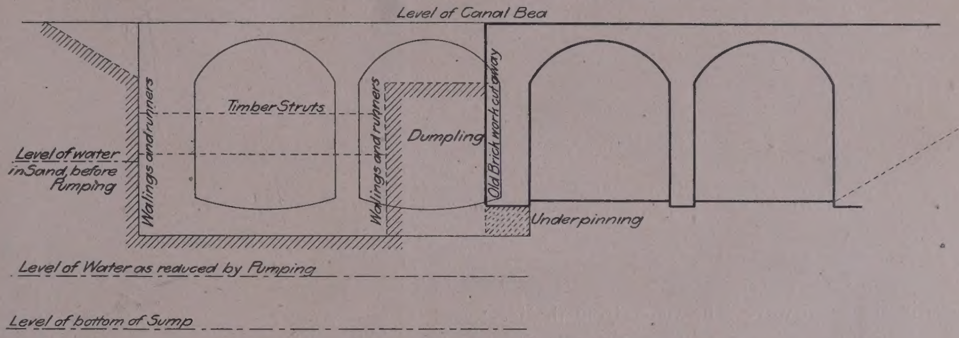
Letters to the Editor.

A Novel Derrick Support.

Sir: The erection of an addition to the Raleigh Hotel in Washington, on a small adjoining tract of land developed a novel method of operating a large derrick in a cramped space. Owing to the small size of the site on which the addition is being built and the nature of the work, it was not possible to use the ordinary derrick with stiff legs weighted down by boxes of brick and stone. But to erect such a building without at least one derrick was also an impossibility. Therefore, the contractor was forced to devise a hoisting device to fit the conditions, which he did, as shown in the illustration.

The wall of the hotel building was pierced at the eighth floor, exposing one of the heavy steel beams of the framework. To the top of this beam a steel plate was riveted and this was reinforced by steel brackets riveted to the bottom of the beam. This formed the foot of the derrick, on which rests the pivoted shoe of the jib. The wall was pierced again at the eleventh floor, and to the top of the beam a triangular steel plate was riveted. The wire cables run through a pulley block fastened to this plate by a welded ring. With this derrick it is possible to reach every part of the site and far out into the street, without obstructing the work.

B. R. Winslow.



Underpinning a Canal on the London & South Western Ry.

Conveying Plant, New York Anchorage, Manhattan Bridge.

Sir: We note with considerable interest the article in your March 3d issue, page 293, in relation to excavating and concreting the New York Anchorage of the Manhattan Bridge. In this article you make mention of the fact that there has been furnished and installed a 24-in. Robins belt, manufactured by the Diamond Rubber Co., of Akron, Ohio. This information is erroneous, for as a matter of fact we designed this conveying outfit and furnished all the material. The conveying belt proper was made for us by the Diamond Rubber Co. and in the construction of this system, the Robins patent troughing idler was employed. We did this job complete for the Williams Engineering & Contracting Co., and feel you should make some mention of the fact in your next issue.

Yours truly, Webster Mfg. Co.

New York, March 7.

[The Robins Conveying Belt Co. has also pointed out the facts mentioned above, and furthermore states that the conveyor is 500 ft. between centers and not 1,000 ft., and is by no means the longest 24-in. belt conveyor in operation. The Diamond Rubber Co. has nothing whatever to do with the manufacture of the Robins belt.]

Foundations in Running Sand.

Sir: The article on "Foundations and Underpinning in Mud and Sand" in your issue of Feb. 10 reminds me of an interesting piece of work I was connected with some years ago, on the widening of the London & South Western Ry. in England. A short tunnel of two archways under a canal was duplicated, and the foundations being on running sand, great care had to be exercised so as not to damage the original structure, more especially as the foundations of the new structure were designed below the level of those of the old one, which was constructed about 70 years ago. The accompanying diagram is a sectional elevation of the archways, the old work being shown by thick lines and the new by thin lines. The angle of the canal with the railway was very acute, and the archways were 200 ft. in length.

The first thing to be done was obviously to commence drainage operations so as to bring the water in the "running sand" below the level of foundations. This was done by means of a sump composed of cast iron cylinders 9 ft. in diameter, sunk 10 ft. below the foundation level. The bottom ring of this cylinder was perforated with numerous small holes, and material to form an inverted filter bed was deposited in the bottom of the sump. On the top of this filter bed was placed a perforated circular iron plate, of nearly the same diameter as the cylinder, in two segments, which was secured by a diver to the cylinder by struts against the flange of the bottom ring. The sump was thus secure against any boiling action in the running sand, while the water was free to flow, without carrying sand or silt with it to any serious extent.

Pumping was done by a 4-in. centrifugal pump, and carried on intermittently day and night, the ejected water being conveyed for 500 ft. clear of the work in a wooden trough.

As soon as the pumping was commenced the canal was closed by a dam at each side of the work, traffic being carried on by transhipment over a temporary bridge. At the same time excavations were proceeded with in the way shown by hatching on the sectional elevation, and it was found when the level of the water-bearing sand was reached that it was quite firm, and dry enough to be easily handled, a great contrast to its state before pumping had taken effect.

The foundation level being reached the inverts were put in, with the exception of that portion under the dumpling, and the building of the abutment and pier proceeded with. When the arches were turned, the dumpling was removed, the old abutment underpinned, and the remainder of the invert put in.

The underpinning was done with concrete in short lengths, grouting being run in at the finishing level, the top plank of the forming being slightly set back, with its upper edge a few inches above the foundation of the old work so as to put a head on the grout, thus ensuring thorough contact with the old work. The work was completed in four months and no settlement nor cracks in the old structure occurred.

I was also connected with a very interesting work in Glasgow, Scotland, where a railway tunnel was constructed under one of the principal streets, almost entirely in very fine running sand. The accompanying cross-section shows an outline of what was done.

The temporary drainage tube, constructed some time before the cut and cover tunnel work was commenced, was of malleable iron 4 ft. in diameter, covered with numerous small perforations. It was in three segments put together inside a shield, the excavation in front being performed by a water jet, which was turned on when everything was ready for the shield to be pushed forward, this being done by hydraulic jacks in the usual way. The water from the jet along with the sand carried with it was conveyed back through the tube in a pipe and got rid of at suitable places.

This work was very successful; no subsidence occurred, and the buildings on each side of the street suffered no damage. In this case also the running sand was altered to a firm condition, and easily excavated. The observation sump was for the purpose of seeing how the drainage was acting and when the level of the water in the sand was sufficiently reduced, work on the tunnel was commenced.

Yours faithfully, Grieve Macrone.

Savanne, Ont., Feb. 27.

Reinforced Concrete.

Sir: Much space in The Engineering Record has been devoted to reinforced concrete within the last twelve or fifteen months, the articles containing both theoretical discussions and numerous descriptions of actual cases. The result, however, of comparing these theories with each other and with actual practice is a trifle discouraging. There have been cases given in which beams designed to carry equal loads were about as three to one as regards their moments of resistance. Neither are the various theories propounded in accord. Would it not, therefore, be well to provoke some discussion on the subject, so that the various existing theories may be brought to light and compared and the true theory determined once for all?

Of the various discussions, that which impressed the writer as being most rational was contained in two articles by Mr. George H. Blakeley, M. Am. Soc. C.E., in the issues of May 27 and June 3, 1905. It has occurred to the writer, however, that the subject could be put in a more rather practical form by the solution proposed herewith. The following assumptions are made:

1. A plane section of the beam before bending remains a plane after deflection, or, in other words, the strain in each fiber is proportional to its distance from the neutral axis.

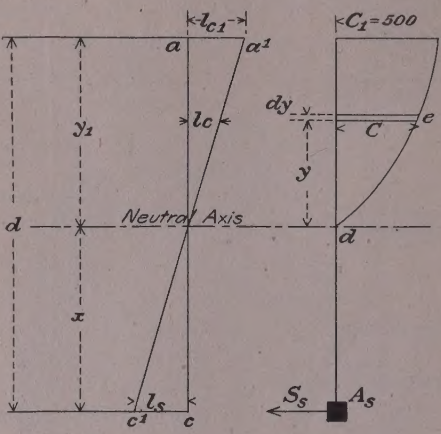
2. The modulus of elasticity of the steel is constant within the elastic limit and is equal to 29,000,000.

3. The modulus of elasticity of concrete in compression is not constant but decreases as the fiber stress increases, and that consequently the latter is not proportional to its distance from the neutral axis.

4. This discussion has reference to the conditions when the beam is loaded only to the limit of safety, and consequently no account is taken of the shifting of the neutral axis.

5. The initial modulus of elasticity of concrete in compression is taken to be 3,000,000. This is for 1:3:5 Portland cement and stone concrete.

6. The greatest safe unit stress for concrete in compression is taken at 500 lb. per square inch; and for steel in tension 16,000 lb. per square inch, and the tension in the concrete is neglected.



Referring to the figure we have the following notation:

E_S = modulus of elasticity of steel = 29,000,000.

E_O = initial modulus of elasticity of concrete = 3,000,000.

C = compressive stress in concrete at distance y from neutral axis.

C_1 = compressive stress in concrete at top of beam = 500 lb. per sq. in.

y_1 = distance from neutral axis to top of beam.

y = variable distance to neutral axis (less than y_1).

d = effective depth of beam.

E_C and E_{C1} = moduli of elasticity corresponding to C and C_1.

l_C = strain in concrete due to C.

l_{C1} = " " " " " C_1.

x = distance from neutral axis to reinforcing steel.

S_S = unit stress in the steel.

l_S = strain in steel due to S_S.

A_S = area of steel in square inches.

From experiments it has been shown that the modulus of elasticity for concrete in compression varies in accordance with the following law: $E_C = E_O = 600\ C$ (Blakeley).

Therefore

$E_{C1} = E_O - 600C_1 = 2{,}700{,}000$, and $l_{C1} = C/E_{C1} = 1/5{,}400$.

We have from the figure y/l_C = a constant, $y_1/l_{C1} = 5{,}400y_1$, and $y_1/l_{C1} = x/l_S = 5{,}400y_1$, or $l_S = x/5{,}400y_1$. Since $E_C = C/l_C = E_O - 600\ C$, $C = l_C E_O/(1 + 600l_C)$. But $y_1/l_{C1} = y/l_C$, or $l_C = l_{C1}y/y_1$, which substituted gives $C = l_{C1}\ E_O\ y \div (y_1 + 600l_{C1}y)$. Inserting numerical values this becomes

$$C = 5{,}000y \div (9y_1 + y) \qquad (1)$$

This equation gives corresponding values of C for assumed values of y, and is the equation of the curve def.

If we consider a beam of width b, the resisting moment of the concrete in compression becomes

$$M_C = b\int Cydy = 5{,}000b\int_0^{y_1} \frac{y^2dy}{9y_1+y} = 170by_1^2 \qquad (2)$$

If we now fix the safe unit stress for the steel, we have all the data necessary for determining the position of the neutral axis, the area of the steel and the total moment of resistance. For $M_S = M_C = A_S\ S_Sx = 170\ by_1^2$ and $d = y_1 + x$. But $S_S = E_Sl_S$ and $l_S = x/5{,}400y_1$. Therefore

$$S_S = 29{,}000{,}000x/5{,}400y_1 \qquad (3)$$

$$y_1 = 290{,}000d \div (290{,}000 + 54S_S) \qquad (4a)$$

$$x = d - y_1 = 54S_Sd \div (290{,}000+54S_S) \qquad (4b)$$

$$A_S = \frac{M_C}{S_Sx} = \frac{bd\ (170 \times 290{,}000^2)}{54S_S^2(290{,}000 + 54S_S)} \qquad (5)$$

If we assume S_S = 16,000 then these values become

$y_1 = 0.25\ d$,
$x = 0.75\ d$,
$M_C = 170\ b\ (0.25\ d)^2 = 10.625\ bd^2$,
$A_S = 0.008854\ bd$.

The percentage of steel = 0.08854. The total $M = M_C + M_S = 21.25\ bd^2$.

If we assume S_S = 8,000, we have

$y_1 = 0.4d$, $x = 0.6d$,
$M_C = 27.2bd^2$,
$A_S = 0.00567bd$, the
percentage of steel = 0.567 and
$M = 54.4bd^2$.

Hence we see that in a rectangular beam of given dimensions we may increase its moment of resistance 2½ times by making the stress in the steel 8,000 lb. instead of 16,000 lb. per square inch; but at the same time we increase the percentage of steel more than six times.

The problem, then, is to find what percentage of steel will give the greatest resisting moment per unit cost, and this is the most economical ratio.

If we assume the costs of the concrete per cubic foot, and of the steel per pound and let K = cost per lineal foot of beam then $K = f\ (y_1)$ and $M = F\ (y_1)$.

Let $k = M/K$ = ratio of moment to cost.
Then $k = F\ (y_1)/f\ (y_1)$.

If we then place $dk/dy_1 = o$, and solve for y_1, we obtain values of the latter, one of which will make k a maximum. This solution involves some difficult algebraic reductions, which are omitted here. Suffice it to say that if we assume as relative values, 35 cents per cubic foot for the concrete, and 2 cents per pound for the steel we obtain $y = 0.53d$ which gives the most economical position of the neutral axis, and this value substituted in the previous equations, reduces them to the following:

$M_C = 47.75\ bd^2$ (1)
S_S = 4762 lb. (2)
$A_S = 0.02124\ bd$ (3)
Percentage of steel = 2.124 (4)
M (total) $= 95.5\ bd^2$ (5)
$K = 0.3874bd$ cts. per lin ft. (6)
$M/K = k = 247d$ (7)

These results show the fallacy of employing high tension steel. Indeed, as all medium and low grade steels have approximately the same modulus of elasticity, viz., 29,000,000, it follows that any steel which has an elastic limit as high as, say, 15,000, and an ultimate tensile strength of 30,000 is more than sufficient, provided, of course, it were possible to get such a product which would be uniform.

New York, March 3. W. M. Farrar.